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IN THIS ISSUE

1941
CHRISTMAS JINKS
of the
WILDCAT COMMITTEE
CALIFORNIA OIL AND GAS ASSOCIATION
★
WEDNESDAY, DECEMBER 17
7 P.M.
BILTMORE BOWL
Los Angeles
$5 a plate **Informal**

San Joaquin Valley Oil Producers Assn. Annual Banquet..... 3
New Shell Crude Oil Pumping Stations..... 4
A. I. M. E. Annual Pacific Coast Meeting (Cont.)..... 7
Practical Application of Equilibrium Relations..... 11
Tank Truck Gauging Committee Report..... 15
The Partial Volume and Its Significance (Cont.)..... 16
Gas Engine and Compressor Committee Report 18
Los Angeles Basin Development..... 20
Laugh This Off..... 25
San Joaquin Valley Development..... 26
Coastal District Development 29
Business Directory..... 32

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San Joaquin Valley Oil Producers Assn.

Hold Annual Banquet Meeting

Problems of the industry which "furnishes the life blood of war" were discussed by speakers at the annual banquet of the San Joaquin Valley Oil Producers' Association, Dec. 4, at Bakersfield. Governor Sam H. Jones, of Louisiana; Dana Hogan, president of the association, and E. E. Pyles, chairman of the production committee for District 5 of the Petroleum Coordinator's office, spoke to more than 400 members and guests at Hotel El Tejon.

Governor Jones, who flew to Bakersfield from the Louisiana capital, said: "Before I became interested in politics, I was a lawyer in an oil state, and that means that I searched a great many titles. Then, when I did enter politics, I was further involved in the oil industry in clearing up the mess left by my predecessors. And, being from the south, I am traditionally concerned, as everyone in my section is, with the necessity for preserving state rights."

The principal means to avert "policing" of the petroleum industry by the federal government, the governor said, is by organizing an adequate conservation plan and abiding by it.

Mr. Pyles said that he felt that "Mr. Ickes and Deputy Coordinator Ralph Davies are sincere when they say that if the industry cooperates with the government during the emergency it will still be free when the emergency is over. In line with this the production committee has drawn up a conservation plan for this district. This plan has been presented to Washington and when Mr. Hogan and I fly there Saturday night to attend the first meeting of the petroleum council for national defense Monday morning, we hope to be able to bring back word of its approval.

"When that happens, I expect to call a state-wide meeting in Los Angeles immediately, so that the plan can be explained in detail to all of you."

Left to right: Allen Jergins, C. C. Spicer, E. E. Pyles, Gov. Sam H. Jones of Louisiana, Dana Hogan, R. A. Broomfield, Jr., Geo. Haberfelde.

New Shell Crude Oil Pumping Stations

To Handle 40,000 Bbls. Daily

By Glenn Gill
J. B. Gill Corp.

The J. B. Gill Corp., under the supervision of R. M. (Bob) Allen, is rapidly completing construction of the first of two proposed crude oil pumping stations for the Shell Oil Co., Inc., at their property in the Ventura oil field. The second pump station, to be called the Conejo Plant, is approximately 40 miles south of the Ventura unit.

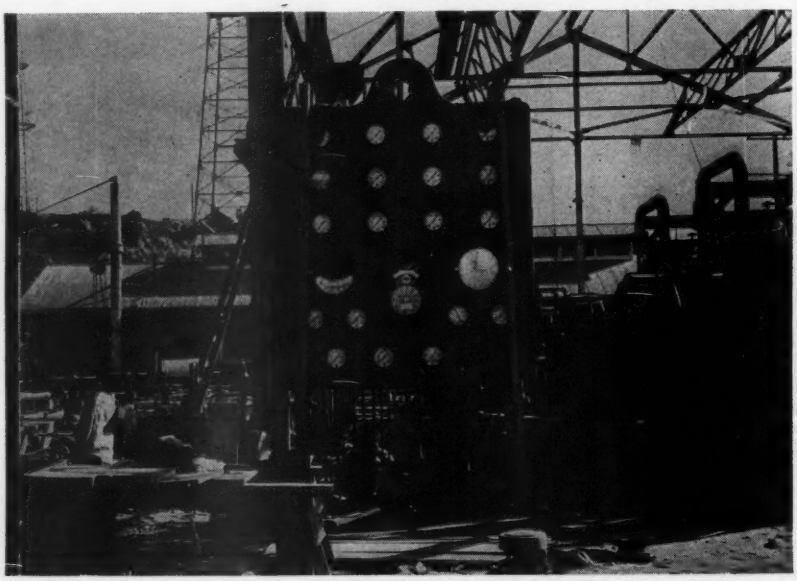
The two stations are designed to handle approximately 40,000 barrels of crude oil per day through a new 10-inch line, laid recently by the Macco-Robertson Pipeline Construction Co. as part of the same project, from the Ventura oil field to the Shell Oil Co.'s Wilmington refinery. At present, the Ventura station, which has been running since October 12, 1941, is pumping 25,000 barrels per day with two of its four units. The addition of the Conejo Plant and the completion of the fourth unit at Ventura will permit the full capacity of the pipeline to be utilized.

Design

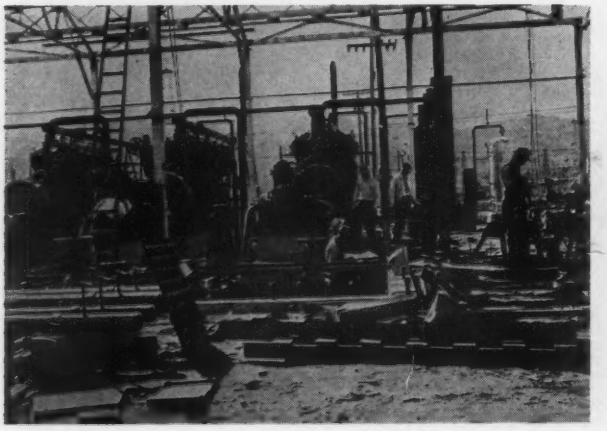
The design, worked out by the Engineering Department of the Shell Oil Co., Inc., is conventional in most respects. Particular attention, however, was given to the piping arrangement, resulting in an unusually pleasing appearance for a plant of this type. The office is incorporated in the main building with all instrument piping being carried to a central board located there.

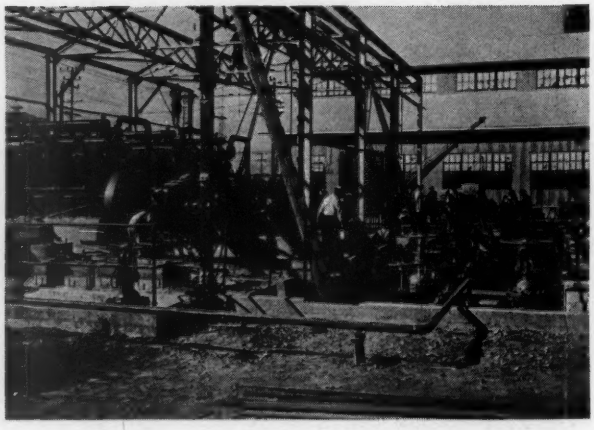
All piping is exposed with the suction and discharge headers manifolded to permit the units to be operated three in series, or in parallel in units of two operating in series. The latter two stage method of operation will be used when running at full capacity.

The pumping equipment consists of 6-cylinder, 275 horsepower, Type P.V.G. Ingersoll-Rand gas engines driving, through a 8.96:1 Westinghouse gear assembly, 4-inch, 4 stage, Ingersoll-Rand centrifugal pumps. The engines develop their rated horsepower at 400 r.p.m. The resulting speed of 3600 r.p.m. at the pumps delivers 22,000 barrels of crude oil per day per unit at a differential head of 500 pounds. When pumping in two stages the discharge pressure will be approximately 500 pounds after the first stage giving a final line pressure after the second stage of 1000



Central Instrument Panel.





Left: Pumping units. Right: General construction view.

pounds. The Conejo station will operate at the same pressures using two pumping units in series, each consisting of a 485 horsepower Ingersoll-Rand gas engine, a Westinghouse step up gear, and a 6-inch, 4 stage Ingersoll-Rand centrifugal pump.

An unique feature of the Ventura station is the system of cooling the engine jacket water and crankcase oil and the step up gear assembly. The equipment was furnished by the Industrial Engineers, Inc., following the Shell Oil Co.'s design, and consists of a large, gas engine driven, fan operating behind a cooling surface divided into two sections. The larger section, made of the conventional radiator type surface, cools the engine jacket water from 160°F. to approximately 145°F. The smaller section composed of copper tubes cools the water running to the oil coolers from 145°F. to 120°F. The efficiency of the tubes in the smaller section is greatly increased by making numerous fine cuts on the surface leaving the slivers of metal attached. The resulting increase in surface area and air turbulence gives a higher rate of heat transfer. Turbulence within the tubes is obtained by the addition of fine copper wire. The water going to the oil coolers is taken off the discharge side of the 145°F. jacket water system through a throttle valve, cooled to 120°F., and after leaving the oil coolers, reintroduced into the jacket water on the suction side at 130°F.

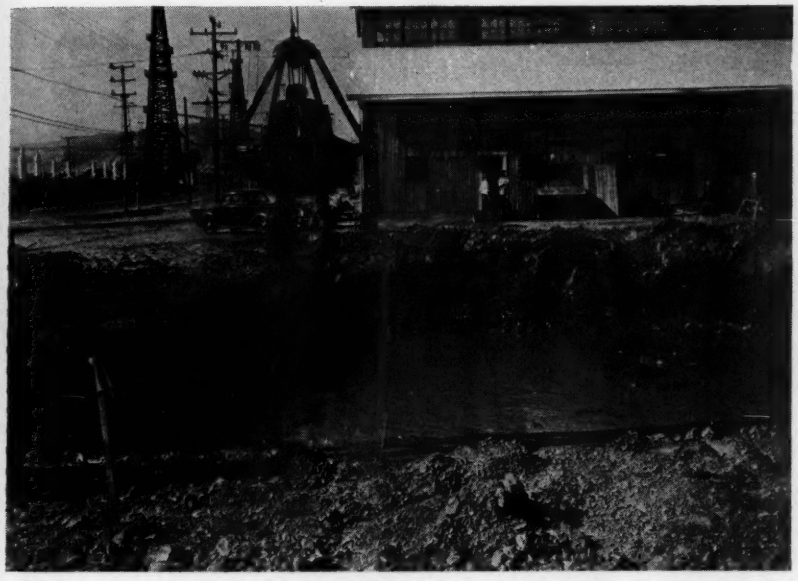
Other features of the plant are the Burgess mufflers, Smith recording and indicating flow meters, and the large 12-inch twin type oil strainers.

Construction

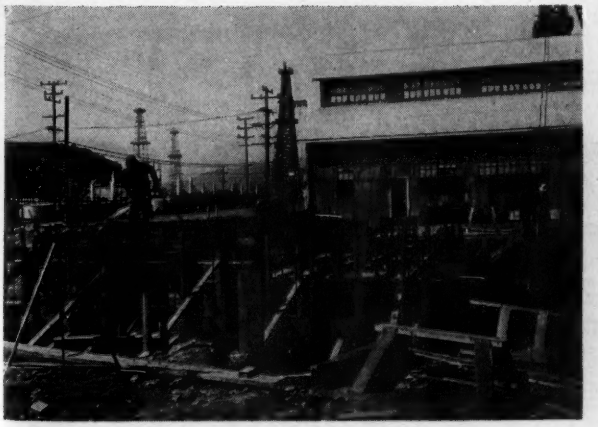
Construction was started with the object of placing the units in service as soon as possible. Accordingly, the work was laid out and proceeded with this objective in view.

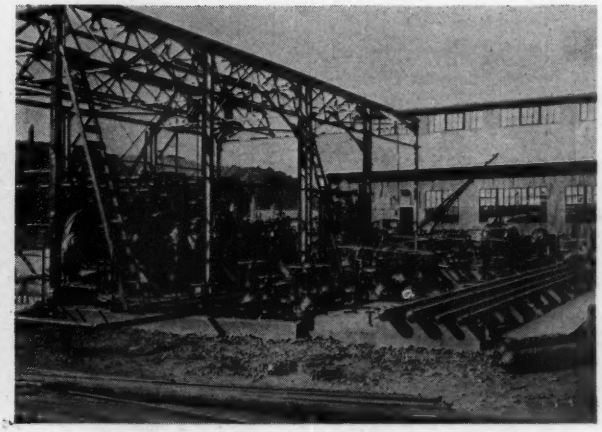
Construction difficulties were confined to the presence of numerous underground springs on the site, bringing water to within 2 feet of the surface and requiring the constant use of pumps. This, combined with the extremely sandy soil, produced a highly unfavorable condition. To offset this, all concrete structures had been designed to be carried to a bedrock (hard pan) consisting of large boulders underlying the area at a depth of approximately 8 feet. The buoyancy provided by the water was overcome by making all trenches very heavy and securing them to the main block carrying the engines by reinforced concrete beams.

Work started on the Ventura station, Aug. 4th, 1941 and the first three units were ready to run by Sept. 27th. Careful planning and anticipation of all problems by the Shell Engineering Department made possible the completion of this part of the work ahead of schedule.



Excavation view showing water level.





Left: Pumping unit foundations. Right: Oil piping manifolds.

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STANDARD OIL COMPANY OF CALIFORNIA

Progress of Petroleum Industry in California

Reviewed at A. I. M. E. Annual Meet

(Continued from Last Issue)

The remainder of the sand, approximately 72 feet, occurs between 11,010 and bottom. These sands may be the equivalent of the Paloma producing zone.

"The B-12-12 sand, discovered by Western Gulf B-12-12 early during the current year, is at present confined to the easternmost producing well within the Paloma Field. This well's productive zone includes 496 feet of formation, of which an estimated 260 feet is sand. The upper 90 to 125 feet of this sand occurs as a replacement of the Chert zone and a small portion of the immediately overlying Brown Shale.

"So little is known at present of the distribution of this sand that it does not merit a great deal of mention other than to say its featheredge lies somewhere between Western Gulf B-12-12 and the next producer to the northwest, Western Gulf A-34.

"A total of nine wells has been drilled to the Stevens sand in the Paloma area. All of these wells are capable of producing with the exception of two, Ohio Oil Co. A-8, located near the south quarter corner of Section 32, T. 31 S., R. 26 E., and Union Oil Co. Morgan No. 81-14, Section 14, T. 32 S., R. 26 E., (abandoned 9-30-41). A-8 was the first in the area to penetrate the Stevens zone. Although the prospects for production seemed good, the well failed to produce and has since remained something of a mystery. Union Oil Co. Morgan No. 81-14 penetrated approximately 200 ft. of sand believed to be the equivalent of the B-12-12 sand. This sand did not, in the opinion of the operator, warrant a test. Western Gulf Oil Co. Symons Bros. Development Co. No. 12-7 is now drilling at 11,021 feet. This well is located in Section 7, T. 32 S., R. 27 E., and is lower structurally than the Union Morgan No. 81-14.

"The seven productive wells, three of which were drilled by the Ohio Oil Co. and four by the Western Gulf Oil Co., have an average depth of 10,467 feet. The deepest well drilled in the field is Western Gulf 74-3, which was carried to a depth of 11,422 feet and later plugged back to 10,700 feet.

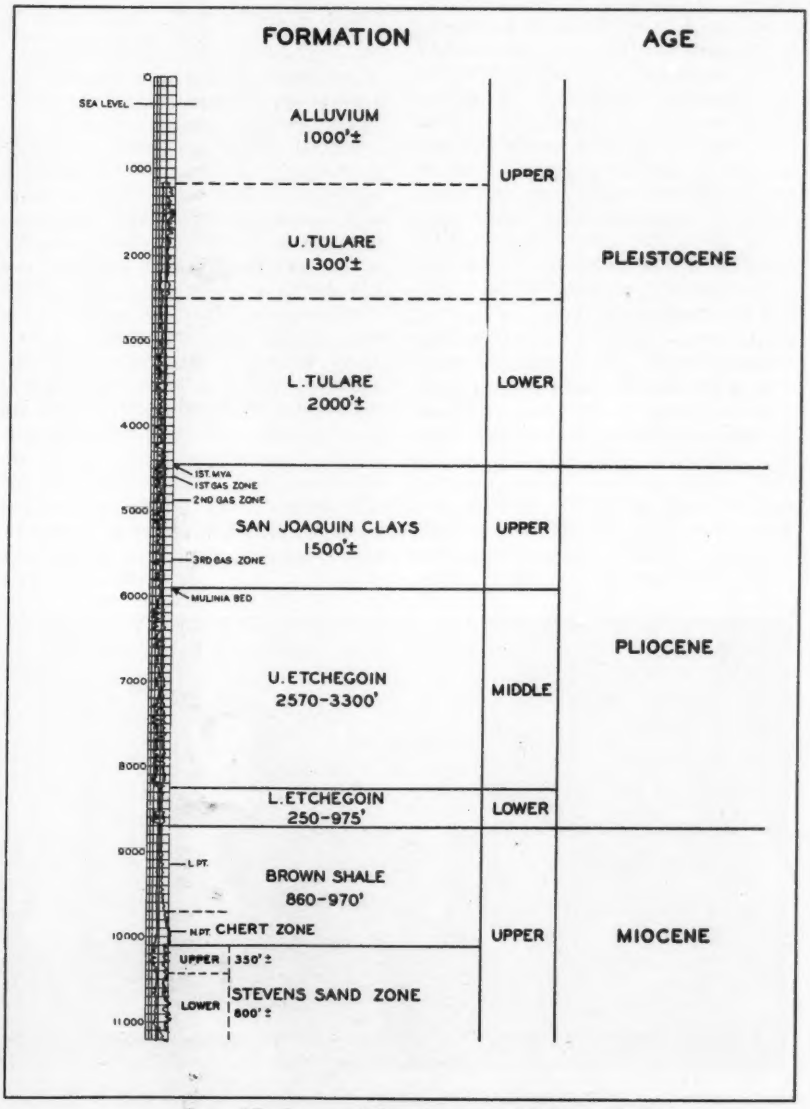
"The drilling program to date has been to set a 13⅜-in. surface string between 1200 and 1300 feet. A 7-in. water string is then set above the sand at approximately 9500 feet, followed by a 4¾-in. shop perforated liner on bottom. A majority of the wells are completed with 2-in. tubing.

"The ultimate productive area has been estimated to be from 3000 to over 5000 acres. A number of additional wells must be drilled before the field is definitely defined."

Norris Johnston, physicist for General Petroleum Corp., abstracts his contribution to the forum, "P. V. T. Relations," thus: "This paper describes what is meant by P. V. T. relations. In the case of the Paloma reservoir, dew point, condensation, and revaporization are discussed as functions of reservoir pressure. Applications of such information to methods of production of the oil field and to proof of existence of a black oil band are discussed."

W. H. Geis, assistant to the president of Union Oil Co. of California, discussing "A Plan for Operation," said, in part:

"Soon after the Paloma field was discovered it was realized that all the hydrocarbons in the reservoir existed in the gaseous phase. This condition was confirmed over a large area. Therefore, if the field was to be properly exploited with the greatest ultimate recovery of condensate, the hydrocarbons in the reservoir must be produced in the single or gas phase. They must be cautiously extracted with the least possible reduction of the natural pressure. If



From "Geology and Development of Paloma Field."

this could be accomplished, or if artificial pressure control was utilized the condensation and underground loss of the valuable distillate was preventable, otherwise not.

"It was contended, without dispute, that if the field were exploited in the competitive fashion whereby each operator sought to complete the first, and the most, wells on his property, that only 1/4 to 1/5 of the otherwise recoverable liquid (condensate) would be saved in the tanks. These estimated recoveries were never fully authenticated but the accepted figures were 21,000 barrels per acre recovery by pressure control and 4,000 to 5,000 barrels per acre without such control. . . . Opportunity for a handsome profit, and an assured one, could be changed easily into a discouraging financial failure.

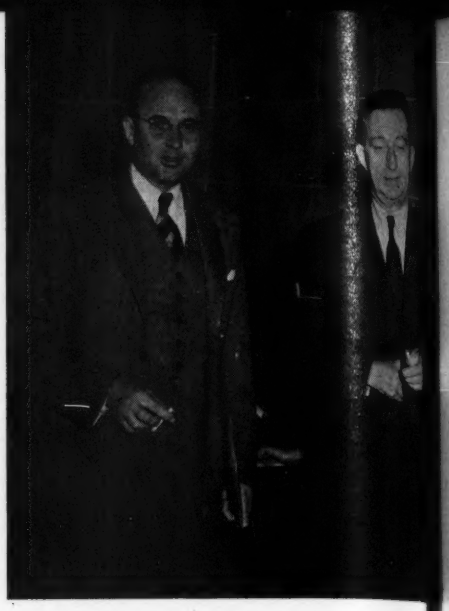
"Prevention of such a loss was quite simple. Through a central plant the liquid could be recovered at a predetermined and practical rate, as a water white product of about 60° A.P.I. gravity containing some 50% of fighting grade aviation gasoline. The residual gas could be returned to the reservoir to provide pressure control, later extracted and sold as dry gas. All would benefit by pressure control, some more, others less, but everybody would be ahead of the competitive system from the standpoints of both reduced costs and increased recoveries.

"A few operators were sufficiently rugged in their individualism, an otherwise admirable characteristic, to insist that the specific relationship, or equity, of each land parcel to the whole must be determined. If this were not done they would, and did resist the plan which necessarily had to be unanimously accepted. Equities are apt to involve not only the area of participation but sand thicknesses, porosity, permeability, saturation and many other factors varying from place to place. There are a number of important intangibles which may never be known but upon which specific equities may depend. Even complete knowledge of one variable within a group of several is of little or no help in the solution of such a problem.

"Geological structure in itself was a variable in the equation. The area had been 'shot' by seismic surveys many times both before and after the discovery, but while each map differed from another yet a composite of all could be used as indicative of the underground configuration. The well data indicated that the Paloma Sand thickened shoreward along the axis and to the southeast. Permeabilities decreased in the opposite direction becoming practically zero west of the section line separating sections 4 and 5 (T. 32 S., R. 26 E.) beyond which two dry holes had been drilled in section 5, T. 32 S., R. 26 E. and section 5, T. 31, S., R. 25 E.

"Southeast from the point of zero permeability seven wells had been completed proving four miles along the structural axis. These wells were highly productive and revealed the reservoir conditions. Therefore while a freshman geologist could tell that the structure was large and of great potentiality no one not present when the sand was laid down could determine the specific relationship of each land parcel to the other parcels or to the whole unit area. This, however, only introduced the gambling element for which the oil operators are reputedly well known but which failed to materialize in this case.

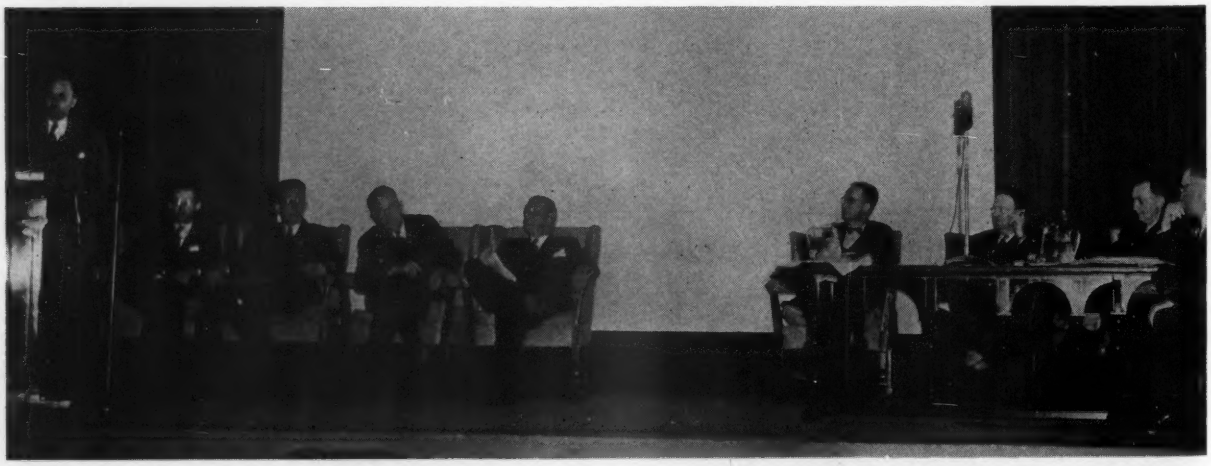
"The operators all knew the conditions and the Committee had to find a yardstick with which to measure them. It settled the quesion by deciding that participation should be on the basis of acreage only. If 5,000 acres were



J. T. Wood, Jr., and William Moeller, Jr.

included with the plan then each 80 acres enjoyed 1.52 per cent of the total recovery from the pool and bore the same percentage of the costs. In accepting this provision the larger operators and owners had to grant concessions since the greatest known sand thicknesses were on their lands. The decision may or may not have been fair but resolved itself into balancing one equity or variable against another. All then that remained was to fix the area and the boundary line. This presented 'Field Day' possibilities for trading proclivities.

"Most of the companies had previous experience with unitization efforts in California and realized the tendency of each unconsciously to be influenced by his own interests. Even when eminently fair, motives are frequently misunderstood. Therefore, the Committee decided to turn the entire matter over to a complete outsider. Someone with no California affiliations, prejudice or favoritism, but with wide experience in retrograde production and unitization. Pref-



Ready to tell about Paloma field from all the angles were, left to right, W. T. Wood, Jr., Norris Johnston, John F. Dodge, Paul Paine, Howard Pyle (pinch hitting for W. H. Geis, who is in Washington), H. N. Marsh, R. P. Huggins, William Moeller, Jr.,, E. J. Kennedy, Jr.

erably it should be one who had never even heard of Paloma. It was tacitly decided, if not actually, to abide by the decisions of such a person or firm if one of the somewhat unusual qualification could be found. A sub-committee was appointed to find the qualified people and report their names to the Operators Committee which would then make the selection.

"Members of the sub-committee journeyed into Texas and Oklahoma and personally investigated the qualifications of many individuals and consulting firms, presented a list thereof to the Operators Committee, and a selection was finally made. The engineering firm selected accepted the committment and were charged by the Committee to do the following:

"1. To study the physical conditions in the field in confirmation of the retrograde aspects,

"2. To make adequate field tests on a commercial basis in confirmation of laboratory tests,

"3. To determine upon the area to be unitized,

"4. To prepare and present to the Committee a complete plan for unit operations,

"5. Upon the request of the Committee to design the proper type of plant and supervise its construction,

"6. To consult with the landowners and explain all features of the Plan,

"7. To prepare a Consent Agreement for the landowners' signatures permitting the lessees to join in the plan,

"8. To assist the lessors in obtaining changes in the various leases where required, and

"9. To do whatever was necessary to assure a soundly engineered Plan.

"It must be admitted that the consulting engineers performed their work in an admirable and professional manner. They could analyze most of the factors and reach sound conclusions but there was one thing they could not analyze and that was the idiosyncracies of human nature.

"Before the consultants were employed an engineering report was available from the laboratories of the California Institute of Technology. This report was conclusive and set forth the pertinent characteristics of the gaseous mixture. Similar investigations were in progress at the laboratories of the Gulf Corporation in Pittsburgh so that when the consultants had concluded their report the Committee had the benefit of three independent investigations (and conclusions). It later proved that all the reports were so nearly identical that no doubt could possibly remain as to the manner by which the field would have to be developed and produced.

"This story of the unitization effort is told in some detail in order to indicate that the Operators Committee went to extremes to limit the personal equation. The Plan failed of acceptance because of two things, first, the refusal of a minority to accept the position of the boundary and second, the possibility of a black oil ring existing between the gas cap and the edge water.

"The consultants reported that a black oil ring might exist between the gas and the water line. Such a ring must be very narrow since little width remains between the known extent of the gas-cap and the position of the edge-water. Even if oil does exist a little simple arithmetic will show that with oil at $1.25 a barrel the land must produce 30,000 barrels per acre to equal the equivalent returns from participation in the unit.

"Considerable criticism developed as to the size of the unit although no one claimed that it was too small. When analyzed as to where it was too large, some contended that it extended too far to the north but not far enough to the southwest; others, too far to the west but not to the southeast. In general the unit was too large in the direction of a competitive company's holdings, not large enough in the direction of one's own, but over-all too large. So universal were these complaints, but conflicting within themselves, that they justified rather than condemned not only the size of the unit but its configuration.

"An essential part of the plan provided that all productive land be included for if any was excluded, and later became productive, the whole unit would be subject to severe drainage. Therefore the tendency was to expand the area solely as a safety measure for those with definitely proved lands. Even if barren lands were included, sacrifices could well be made for the assured protection of all. It was an easy task to delimit the minimum productive area but extremely difficult to outline the maximum limits. To a certain extent flexibility on these factors was provided in the plan although once a parcel was included it could not be excluded except under exceptional circumstances.

"A summary of the 'Paloma Operators' Agreement' follows: The agreement was dated May 1, 1941, and was to become effective after four lessees had signed, representing at least 50 per cent of the unitized acreage, and after the plan had been approved by the State Oil and Gas Supervisor. All lessees were required to sign before July 1, 1941 or thereafter could join the plan only with the consent of the Operators Committee. It remained in effect as long as the lands produced or when terminated by unanimous consent.

"Its preamble set forth that unit operations were in the public interest to conserve a natural resource and prevent avoidable waste. This could be accomplished by the maintenance of pressure, creation of gas drive, and by systematic cycling under a unit plan.

"The agreement further pooled all the land within the participating area for the production of all hydrocarbon substances. As previously mentioned the benefits and burdens were based prorate upon acreage. An Operators Committee was created, representation thereon defined, and directed to 'plan, co-ordinate, and manage or conduct the development and operation of the participating lands.'

"Careful reading of the agreement will indicate that the products produced from the unit belonged prorata to the individual companies and royalty owners and were to be delivered in kind. The Committee was simply operating as the agent of the owners. There was no transfer of title. There were many other important provisions in the agreement which clarified the purposes and the intentions of the parties and references made to the document as a model for unit operations.

"In conclusion it should be remembered that the writer was closely identified with the unitization effort as Chairman of the Engineering Sub-committee and repeats the history as it appeared to him. Criticism for the failure of the plan is not directed at any company or individuals, or groups. In retrospect all seem more or less guilty of adopting somewhat narrow viewpoints in light of the advantages that could have been obtained. Details became over emphasized while fundamentals were forgotten."

R. P. Huggins, manager of Western Gulf Oil Co., in discussing "The Management's Viewpoint," said, in part:

"Higher operating costs, with mounting taxes, augmented by the National Defense outlay, without corresponding increases in the sale price of its products, have compelled Management to call on its engineers and on others to double their efforts to counteract these adverse conditions by streamlining its operations and marketing.

"One of the major problems studied by the industry during the past few years has been that of maintaining bottom hole pressure in a gas-distillate field to increase the ultimate recovery. I believe you gentlemen will agree that we have passed beyond the experimental stage in this work, even going so far as to find that pressure injected into the sands of a normal oil well will increase its production, and thus the ultimate recovery.

"The sand in this field (Paloma) is encountered at 10,000 feet or lower, and

In cooperation with the United States Treasury Department, for the purpose of stimulating interest in sale of defense securities, the Standard Oil Co. of California is constructing and will staff and maintain a building in Pershing Square, Los Angeles, to be known as "Defense House". Ground was broken for this building on Monday morning, Nov. 24, Mayor Bowron officiating by turning the first spade-ful of earth. In the photograph from left to right are Frank Clark, representing the United States Treasury Department, Mayor Bowron, R. B. Kirchhoffer, Assistant District Sales Manager, Standard Oil Co. of California, John R. Richards, Chairman of the Defense Savings Committee for Southern California.

some very hard drilling is encountered. Development costs are thus high. Under a normal or conventional drilling program, one well to twenty acres would call for 250 wells on 5000 acres. The productivity of the sand indicates that a program of this kind would be unprofitable. However, by pressure maintenance we are convinced that less than one-third the number of wells will increase the recovery three or four times, and that the decrease in well costs will more than take care of the pressure system.

"From a conservation standpoint, there is everything to be said for this type of operation. The ultimate in recovery is accomplished in so far as the distillate is concerned, and, after that is exhausted, the gas still remains in the ground subject to use at any time when it probably will be needed most.

"A unit plan of developing and operating is essential in this type of field. By co-operation the whole producing area may be developed with the minimum of input and output wells, so located as to conserve in cost and at the same time secure the maximum recovery. This is also true of the plant facilities necessary to return the gas to the sands, the storage, delivery facilities, and attendant investments necessary in handling products of this nature.

"There is hardly a way that every landowner and lessor in the field could obtain his proper share of the underground reserves without joining in a plan of this kind.

"The absorption by the industry of so much of this high gravity oil as would be produced under individual operations would not only create a problem for the industry but would result in great waste. This oil is valuable for aviation and, as such, should be conserved for our country's needs. Dry gas should be saved for future fuel for our industries."

Paul Paine, consulting engineer, discussing "The Unit Project and the Landowner," said, in part:

"I do not represent any group of landowners, and in fact am speaking now only for one and that is myself in commenting on the lessor's position and point of view in a situation of the Paloma type. Most lessors are inclined to be reasonable and unassertive, to a degree of complacency, in their concern as to the operation of their property. It is the occasional unreasonable landowner who causes a disproportionate share of the underground oil to be brought to the surface through the wells situated on his property and thereby provokes many of the inharmonies and needless capital expenditures. Perhaps a similarity obtains in this regard as to an occasional lessee.

"Producing companies do their share in the course of their competition for lease acquisitions and even by encouraging some lessors to bring legal actions which at least give color to the producer's explanation that he does over-drill or over-produce because he is faced with a dispossess and forfeiture action.

"Another important gap in interest has its inception in the fact that generally the lessor wants income, as big and as early as possible. His interest in the principles of conservation are often secondary and no more than academic. In the immortal words of Hoke Smith, posterity has never done anything for him. He observes often that the lessee on the other hand has refining and marketing units for which a backlog of oil reserves is an essential. He finds that an orderly and relatively slow withdrawal of these reserves is that procedure which appears to conform in most cases to a maximum ultimate recovery and the lowest costs, and at the same time lends itself best to the operating requirements of the lessee integrated company. Possibly a clearer recognition of this difference in mutuality of interests would bring some of the hidden obstacles to unitization out into the open."

William Moeller, Jr., vice-president of Southern California Gas Co., presented "The Gas Company's Viewpoint," saying, in part:

"One of the difficult problems of the Gas Company is to fit its available natural gas supply to its fluctuating market requirements. To a large extent the hourly variation in market requirements during any day are taken care of by "above ground" gas holder storage into which gas is delivered during the off-peak hours and from which gas is withdrawn during the peak hours. To meet the seasonal variations in natural gas requirements, various procedures are used such as seasonal changes in rate of natural gas production by producers to the extent this is possible; the use of so-called 'dry gas' production to augment the supply during winter; the use of underground storage by injecting gas into the underground structure during summer and withdrawing therefrom during winter; by manufacturing gas in standby gas plants, etc.

"Underground gas storage is particularly desirable because it provides a convenient means of conserving gas which might otherwise waste during off-peak periods and making such gas available during peak load periods."

Engineering, Technology, latest news—twice a month in California Oil World.

Practical Application of Equilibrium Relations to Oil and Gas Separation Problems

C. N. G. A. Fall, 1941

By
J. E. Laurance, Standard Oil Company of California

The purpose of this discussion is to illustrate the usefulness of the computation proceedure in solving problems involving separation of multi-component mixtures of oil and gas under various conditions of pressure and temperature. Of recent years, multi-stage separation of well effluents has become an important factor in production practice, and a knowledge of results obtainable is essential to the engineer in both natural gasoline plant operation and oil production. In this work the use of theoretical computations is an invaluable and relatively inexpensive tool; yet there are many problems that go only partially solved because some operators are unacquainted with the fact that it is often unnecessary to set up elaborate experimental testing apparatus to obtain data which are sufficiently reliable for engineering purposes. In fact, in most cases a theoretical analysis will suffice and it is only necessary to obtain enough experimental data to (1) serve as a basis for the theoretical analysis, and (2) make occasional checks on the theoretical results to ascertain that they are reasonably accurate.

Recent investigators of the phase behavior of various types of naturally occurring hydrocarbon systems have provided the industry with vaporization equilibrium constants for individual components which may be used in a large variety of computation procedures. In the low pressure range deviation from the ideal gas laws is only slight, and engineering predictions can be made with a relatively high degree of accuracy. In the high pressure range above, say, 500 lbs./sq. in., the deviations become greater as the critical region for the mixture is approached the deviation is often quite large. Although there is yet much to be learned concerning the phase behavior of mixtures in the extereme high pressure range, investigators have already paved the way for estimating equilibrium constants in such a manner that valuable predictions can be derived. For instance, experimental observations at high pressures have been made on a crude oil-natural gas system by Katz and Hachmuth, on an absorption oil-natural gas system by Weber, on a Gulf Coast distillate-natural gas system by Roland, Smith and Kaveler, and on various two and three component systems by several investigators, noteworthy among whom have been Sage and Lacey and Boomer and their associates. With this information as a background, the engineer is not only enabled to study stage separation of the total well effluent, but is also able to predict volumes, temperatures or pressures, and even phases existing in the formation itself. These theoretical data employed in conjunction with a few substantiating pressure cell tests are therefore opening up a new horizon in the technology of petroleum production.

It is not within the scope of the present paper to give complete illustrations of the computation procedures themselves or to analyze any particular oil and gas separation problem in great detail. In regard to computations, may it suffice to say that after equilibrium constants have been ascertained the computations themselves are usually not as difficult as we have from time to time been led to believe by the appearance of lengthy mathematical analyses. Inasmuch as each investigation is usually a separate problem, involving special conditions and definite materials, compositions according to the locality, this paper will discuss only a few typical examples where the computation procedure has been advantageous in solving problems concerning oil and gas systems.

Multi-Stage Separation

In the early days of the industry it was common practice to deliver crude directly from the well-head into atmospheric storage tanks. For low pressure production this practice was not particularly objectionable because there was not an excessive amount of vapors evolved from the tank and there was little demand for the lighter gasoline fractions. As well-head pressures increased simultaneously with a demand for the lighter gasoline fractions, it soon became apparent that evaporation losses were becoming prohibitive. Accordingly, in order to retain more of the desirable fractions in the oil and at the same time remove a greater amount of the undesirable gaseous fractions, an attempt was made to obtain better separation by approaching a differential vaporization process. Although differential vaporization in the true sense involves an infinite number of flash separations, it can be approached by progressively lowering the pressure in two, three or four steps. Hence, we have stage separation in which the well effluent is flashed and the vapors are progressively removed in one, two or even three separators before the oil is finally delivered to the tanks at atmospheric pressure.

With the advent of the natural gasoline industry and the demand for sales gas deliveries at high pressures, stage separation also became advantageous as a means of conserving energy, and it is seldom that trap operating pressures are established without considering the optimum compression ratio for handling the various gas streams entering the plant. Thus we see that multi-stage separation of high pressure oil and gas well effluents has become an established procedure for the purposes of (1) conservation of materials, (2) separation of components, and (3) conservation of energy. The optimum combination of trap conditions will vary with the pressures involved, the gas/oil ratio, the composition of the materials, the distribution of components desired, and an economic balance. Each general case must therefore be handled separately.

Gas Volume

Figure 1 illustrates the effect of secondary trap pressure on the volumes of gases evolved in a low gas/oil ratio system involving two traps operated in series followed by atmospheric tanks. Conditions are shown with the primary trap operated at both 500 lbs. and 300 lbs./sq. in. for comparison. It will be observed that although individual gas volumes change rapidly as the pressure is altered, the total gas volume or the sum of the three individual gas volumes does not change appreciably. In general, when primary traps are operated in the range of pressures considered, the total gas volume is smallest when the secondary trap is operated at about 50 lbs. to 75 lbs./sq. in. This type of chart is of greatest use in estimating the volumes of individual gases that will be delivered to the natural gasoline plant, the type of field collecting system involved, and the horsepower required for compression.

Gas Enrichments

Figure 2 illustrates the change in pentanes (+) enrichment of individual gases for the same conditions shown on Figure 1. The volume and enrichment of the primary trap gas is of course not affected by the secondary trap pressure. Also, it will be observed that the enrichment in terms of gals./MCF is not appreciably different for 500 lbs. and 300 lbs./sq. in. primary trap gas. Of particular interest is the fact that although the secondary trap gas enrichment changes considerably as the secondary trap pressure is altered, such changes do not affect the pentanes (+) enrichment of the tank vapors to any great

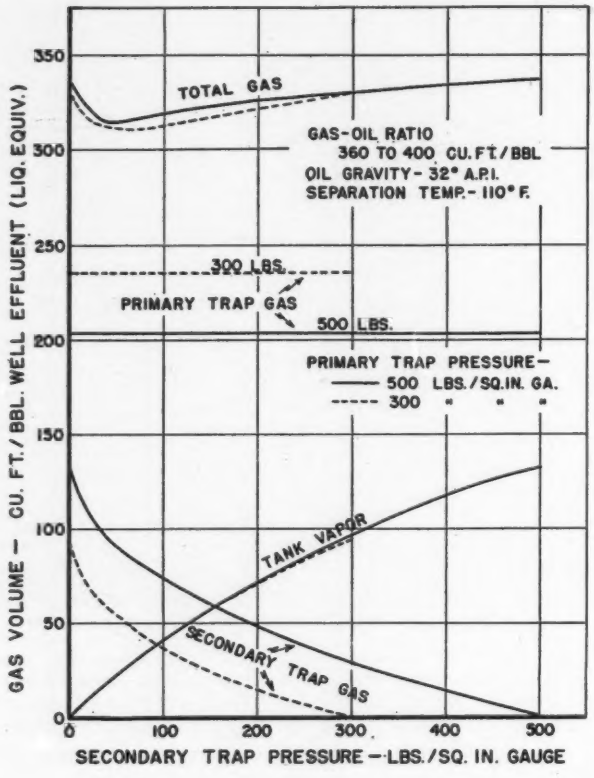


FIGURE 1.

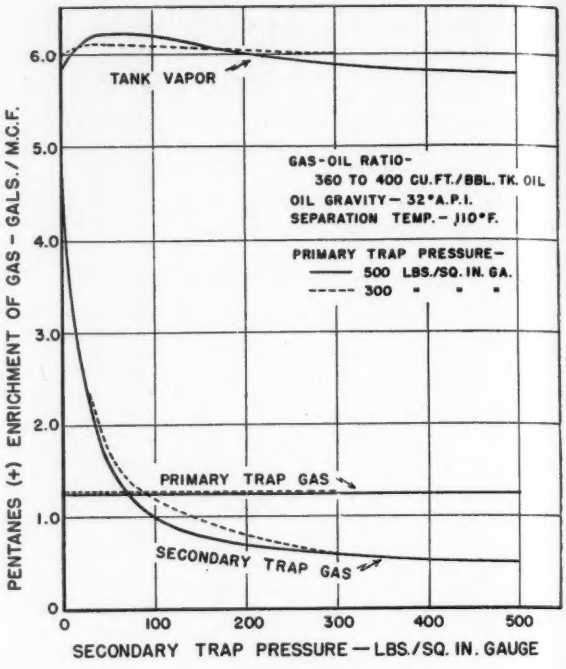

TANK VAPOR
GAS-OIL RATIO-
360 TO 400 CU.FT./BBL. TK. OIL
OIL GRAVITY — 32°A.P.I.
SEPARATION TEMP. - 110°F.
PRIMARY TRAP PRESSURE -
500 LBS./SQ. IN. GA.
300 " " "
PRIMARY TRAP GAS
SECONDARY TRAP GAS
PENTANES (+) ENRICHMENT OF GAS - GALS./M.C.F.
SECONDARY TRAP PRESSURE — LBS./SQ. IN. GAUGE

FIGURE 2.

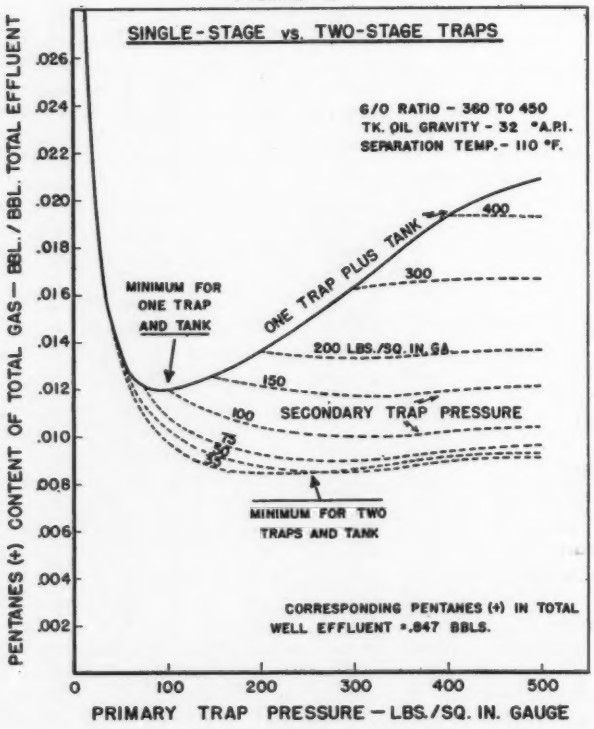

SINGLE-STAGE vs. TWO-STAGE TRAPS
G/O RATIO - 360 TO 450
TK. OIL GRAVITY - 32 °A.P.I.
SEPARATION TEMP. - 110 °F.
ONE TRAP PLUS TANK
400
300
200 LBS./SQ. IN. GA.
150
100
SECONDARY TRAP PRESSURE
MINIMUM FOR ONE TRAP AND TANK
MINIMUM FOR TWO TRAPS AND TANK
CORRESPONDING PENTANES (+) IN TOTAL WELL EFFLUENT = .847 BBLS.
PENTANES (+) CONTENT OF TOTAL GAS — BBL./BBL. TOTAL EFFLUENT
PRIMARY TRAP PRESSURE — LBS./SQ. IN. GAUGE

FIGURE 4.

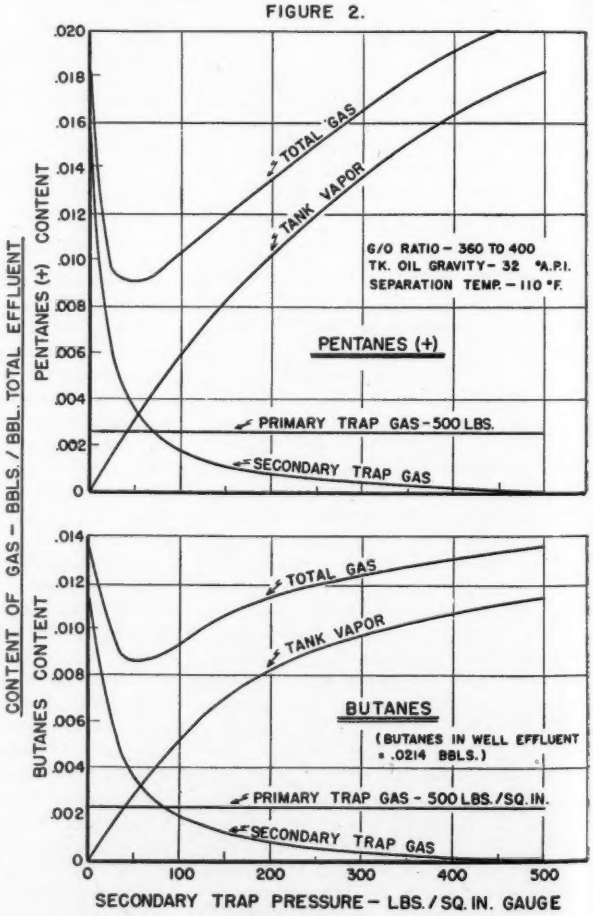

TOTAL GAS
TANK VAPOR
G/O RATIO - 360 TO 400
TK. OIL GRAVITY - 32 °A.P.I.
SEPARATION TEMP. - 110 °F.
PENTANES (+)
PRIMARY TRAP GAS - 500 LBS.
SECONDARY TRAP GAS
PENTANES (+) CONTENT OF GAS - BBLS./BBL. TOTAL EFFLUENT
BUTANES
(BUTANES IN WELL EFFLUENT = .0214 BBLS.)
PRIMARY TRAP GAS - 500 LBS./SQ. IN.
SECONDARY TRAP GAS
BUTANES CONTENT
SECONDARY TRAP PRESSURE - LBS./SQ. IN. GAUGE

FIGURE 3.

extent. It will be remembered that although the enrichment of tank vapors is high, conditions are usually set to give a low volume of tank vapors in comparison with the other gases.

Gasoline Content of Gases

Of more interest than the enrichment of individual gases is the actual amount of butanes or pentanes (+) fractions carried by the gases as shown on Figure 3. These data are obtained by multiplying the gas volumes by the gas enrichments to obtain the actual content. Figure 3 indicates that, for the particular case considered with a 500 lbs./sq. in. primary trap, the minimum content of the total gas with respect to both butanes and pentanes (+) fractions is obtained when the secondary trap is operated at a pressure of 40 lbs. to 60 lbs./sq. in. It is also indicated that the tank vapors will contain from 50% to 80% of the butanes or pentanes (+) fractions in the total gas if the secondary trap is operated at pressures above 100 lbs./sq. in. Where tank vapors are not collected efficiently it is therefore advantageous to operate the secondary trap at a low pressure.

In some cases it may be advisable to operate the secondary traps at pressures other than those indicated to be most nearly ideal. For example, when quantities of low pressure gas and tank vapors are too small to justify separate collecting systems and air must be excluded from the plant intake gas, operation of the low pressure traps at a pressure slightly above atmospheric would result in a larger amount of gasoline fractions being removed from the oil than under the ideal combination of separation pressures, but the net loss of gasoline fractions in tank vapors vented to the atmosphere would be greatly reduced.

Single-Stage Versus Two-Stage Traps

Where well pressures are adequate, it has become common practice to operate primary traps at 400 lbs. to 500 lbs./sq. in. in order that the dry gas may be delivered directly into high pressure sales gas lines without additional compression. However, there are many cases where well pressure is not adequate or where the sales gas is not disposed of at high pressure. In such instances it is advantageous to compare results obtained at various primary trap operating pressures as illustrated on Figure 4. An installation with only one trap ahead of the tank is represented by the solid line curve. For this type of installation the minimum amount of pentanes and heavier fractions is contained in the gas if the trap is operated at about 100 lbs./sq. in. However, the content of the total gas can be further decreased by as much as 30% by installing two-stage traps ahead of the tank. In a two-stage trap system the optimum combination of traps for this particular well mixture is a 250 lbs./sq. in. primary trap operated in conjunction with a 40 lbs. to 50 lbs./sq. in. secondary trap.

The bubble point of the well effluent mixture employed as the basis for computed data shown on Figure 4 was about 2000 lbs./sq. in. at 110°F. Two or more stages of separation would be employed on this type of well, but it is of interest

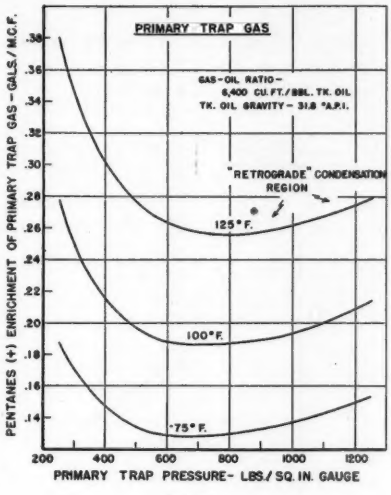


FIGURE 5.

to compare the amount of pentanes and heavier fractions contained in the total gas in one, two and three stages of separation, respectively. For instance, for each 1.0 gal. contained in the total gas in a three-stage separation system, the total gas in a two-stage system would contain 1.4 gals. and there would be over 5.0 gals. in the gas liberated if the well effluent should be flashed directly in the tank at atmospheric pressure.

Although a three-stage separation system is in most instances more desirable than a two-stage system, the case might occur where omitting the secondary trap entirely and collecting only tank vapors could be justified by the attendant removal and recovery of a greater portion of the gasoline fractions from the crude oil. This might be the case particularly if the oil were subsequently handled or stored under conditions unfavorable from the standpoint of weathering.

Temperature Effect

The amount of material flashed from the crude is dependent to a considerable extent upon the system temperature. It should also be kept in mind that the system temperature is usually highest at the highest pressure and that cooling occurs when the pressure is lowered due to the liberation and expansion of the gases. Figure 5 illustrates the effect of temperature on the pentanes (+) enrichment of primary trap gas at various primary trap pressures. It will be observed that a few degrees temperature change under some conditions might alter the enrichment as much as several hundred pounds pressure change.

"Retrograde" Effect

Figure 5 also shows the "retrograde" effect occurring on this particular type of gas which has a moderately high gas/oil ratio of about 6,000 cu. ft./bbl. of tank oil. An interesting illustration of how this might affect actual operations is in the case where an operator has not yet obtained natural gasoline plant facilities for treating the gas and whose gas is lean enough to be delivered directly into the 500 lbs./sq. in. sales gas line if precautions are taken to prevent condensation in the line. To lower the dewpoint of the gas the operator is considering raising the primary trap pressure to, say, 700 lbs. or 800 lbs./sq. in. However, Figure 5 indicates that between 500 lbs./sq. in. and 700 lbs./sq. in. there is very little decrease in gas enrichment, and as the pressure increases above 700 lbs./sq. in. the pentanes (+) content of the gas actually becomes greater. In such a case, it would probably be found that, except for actual processing, cooling is the only satisfactory method of lowering the dewpoint of the gas to any great extent.

Condensate Producing Wells

With the advent of recycling and condensate production, operations at high pressures have become of increasingly greater interest. Here again, computations based on theoretical relations are of great advantage because they supply information which is at times extremely difficult to obtain by experimental means. However, increasingly greater care must be applied in interpreting theoretical results as the pressure is increased. As the critical region begins to be approached, very erroneous results might be obtained if the proper precautions are not taken or if basic data are not first obtained by experimental means.

As a partial illustration of the types of data that might be computed for a condensate producing system, Figure 6 has been prepared for a case where the well is producing gas-cap material and where formation conditions are at or very close to the dewpoint of the total well effluent. These data are for an exceptionally high gas/oil ratio of 42,500 cu. ft./bbl. of atmospheric condensate recovered in the tank following a 500 lbs./sq. in. primary trap. The tank condensate is light in color and has a gravity of 55°A.P.I. As a matter of interest, the amounts of butanes and pentanes (+) fractions in the primary condensates are shown on Figure 6 because such

composition data are not usually obtained in actual pressure cell tests.

The upper section of Figure 6 (Part A) illustrates the trend in condensate recovery when the well effluent is expanded and separation of the resulting condensate is effected in the primary tray operated at various pressures. This plot simulates actual surface conditions where the primary trap temperature is decreased continuously due to expansion of the gas as the pressure is lowered. An interesting feature of this type of operation is that when the pressure is lowered to 500 lbs./sq. in. the cooling effect is sufficient to result in the formation of twice as much condensate as would have been obtained if the temperature had not been reduced below formation temperature. That is, the natural cooling effect doubles the amount of condensate obtained at the lower pressures.

The lower section of Figure 6 (Part B) illustrates the amount of condensate produced from the original mixture if the pressure is lowered while maintaining the temperature at 208°F. (formation temperature). If this pressure reduction should occur within the formation itself, the curves represent the amount of condensate that would drop out in the formation. For this particular case, a reduction of about 1000 lbs./sq. in. in pressure would result in the condensation of about 13% of the pentanes (+) material present. After the condensate has wet the sand its ultimate recovery is somewhat doubtful. It is apparent, therefore, that pressure maintenance is advisable if condensation within the formation is to be avoided. In the illustration given on Figure 6 the gas-cap gas is not very rich. It is understood, however, that there are instances where the formation gas exists at higher pressures and holds a considerably larger amount of the heavier fractions. In such cases there are indications that the amount of pentanes (+) fractions carried by the gas may be decreased by as much as 50% if formation pressure is reduced to, say, 3000 lbs./sq. in. Information of this nature is particularly useful in establishing optimum conditions for recycling operations.

Basic Data Required for Computations

Before computations can be made, it is necessary to obtain a close approximation of the actual composition of the materials present. In most problems this means that the total well effluent composition must be derived from available data. Usually this is done by making actual analyses of the gas and oil streams from the primary trap, after which a materials balance is made for the system by employing the measured volumes of oil and gas. At times when quite accurate data are essential, it is advisable to analyze and measure the oil and gas from the low pressure traps and tanks to obtain the composition and volume of the high pressure trap liquid. At other times, when the oil composition is sufficiently well known, it may suffice for the problem at hand to obtain only an analysis of the high pressure gas. Having this, together with accurate data on the trap pressure, temperature and gas/oil ratio, it is possible to derive an estimate of the total well effluent composition.

Fractional analyses of oil and gas streams should be conducted through hexanes and careful inspection of the heptanes (+) fraction in the oil should be made to estimate its molecular weight. The molecular weight of the heptanes (+) fraction is either determined directly or estimated from the gravity and mid-boiling point or viscosity relationships. Where computations are to be made for exceptionally high pressures, it is often advisable to further divide the heptanes (+) material into two or even three fractions by employing equilibrium boiling point data. This is essential because it is these heavy fractions that show the greatest deviation at high pressures and cause the so-called "retrograde" effect by their tendency to vaporize at high pressures.

After deriving the composition of the mixture, the equilibrium constants for

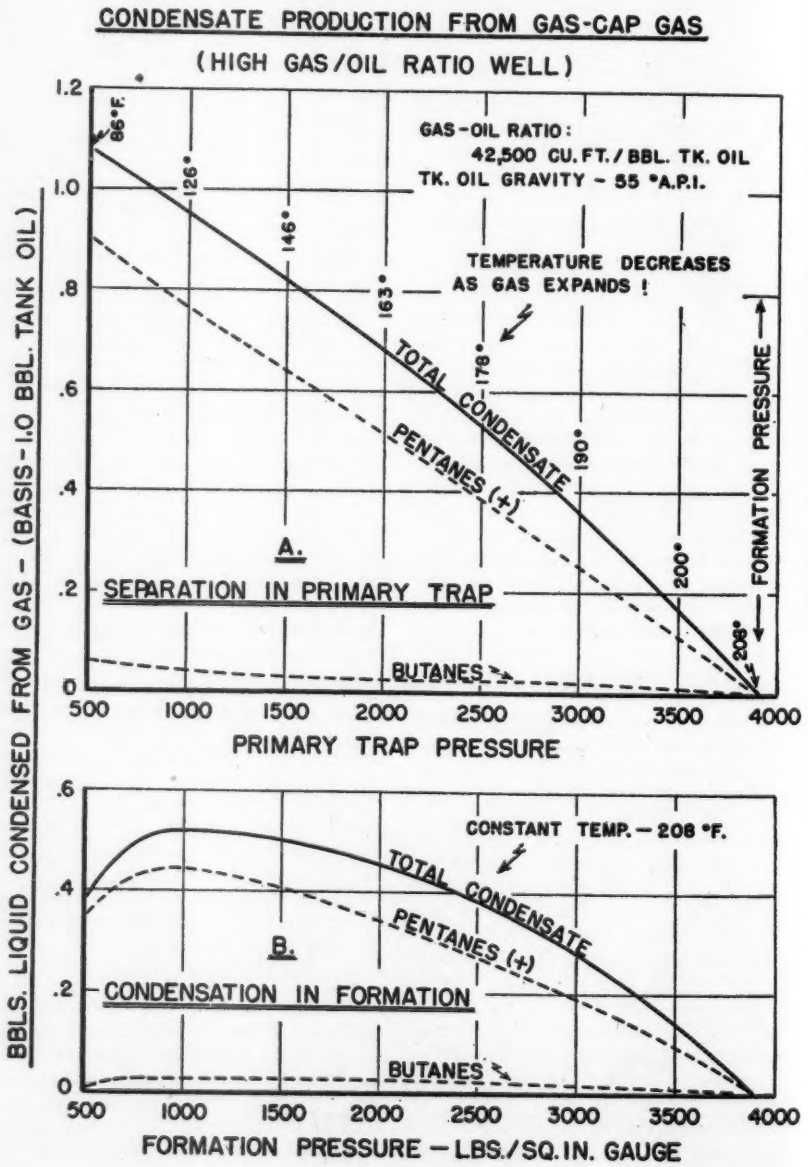


FIGURE 6.

individual components are obtained from available charts or are estimated and the computations are initiated. For low pressure conditions up to, say, 500 lbs./sq. in., little difficulty is experienced in obtaining equilibrium constants that will be sufficiently accurate for most purposes. For higher pressures special care must be taken in estimating the equilibrium constants of the heaviest fractions and the two lightest fractions, methane and ethane. At pressures above about two-thirds of the critical pressure, the computed results may be questionable unless sufficient data are obtained to derive the equilibrium constants or the critical pressure for the mixture by employing pressure cell tests.

Conclusion

In conclusion, it is hoped that the foregoing discussion will serve to illustrate the utility of the computation procedure as a means of solving many of the practical oil and gas separation problems that arise in the industry today. Although there are still many developments to be made, especially in the extreme high pressure range, this should not deter us from employing the computation tool in the many uses where it has already proved practical.

"Studies in Standardization of Gauging Methods for the Shipping of Liquid Petroleum Products by Vehicular Units"

C. N. G. A.
Fall, 1941

Presented by W. B. Parks,
Norwalk Co., Chairman Truck Gauging Committee

In the early days of petroleum, the product in greatest demand was kerosene. The kerosene was transported in drums, or small tanks on wagons drawn by horses. As the kerosene was sold in small quantities, it was convenient to measure it in five-gallon containers, or make deliveries in drum lots.

Later when the horse was replaced with the combustion engine as the means of vehicular power, there became a large demand for gasoline. Larger tanks were installed on motor trucks and larger deliveries were made at any one stop, but the method of measurement was still the same. The truck driver would measure the outage in 5 or 10-gallon containers, keeping his tally with a series of washers on a rod. As the amount of gasoline in service station storage increased, the number of stations serviced by a given truck decreased. This meant that gasoline companies would have to purchase more tank trucks, or find some means of faster measurement. The positive displacement meter to measure gasoline was developed and has since replaced the container and washers.

These methods were not used to measure petroleum products as volatile as natural gasoline, but indicate the improvement in measurement of the commodity out of the tank truck.

Actually the original measurement of the product, whether it be kerosene or natural gasoline is the same, as it is measured in storage tanks strapped to the one-eighth inch.

The tank truck used to transport natural gasoline is calibrated to a total capacity at a marker, set and sealed by the sealer of weights and measures. Basically this method is as accurate as the measurement of the gasoline in the storage tank.

The only means of determining when the gasoline is at the marker level, is through look glasses installed in the dome of the tank. Due to the volatility of natural gasoline, the accepted practice is to load at night, to maintain loading and transportation losses at a minimum. Look glasses become fogged, making it extremely difficult to accurately determine when the gasoline is at the marker level.

When the loader has determined that the gasoline is to the marker, he shuts the loading valve with a rope device attached to the valve wheel, or has to gauge the speed of loading so he will have time to manually shut the valve.

Fogged look glasses, night loading and manually controlled shut off valves all tend to cause the possibility of overloading, instead of under-loading.

Markers are set in the domes of the tanks and as these domes contain from 100 to 200 gallons, it is possible for considerable loss of actual liquids to occur.

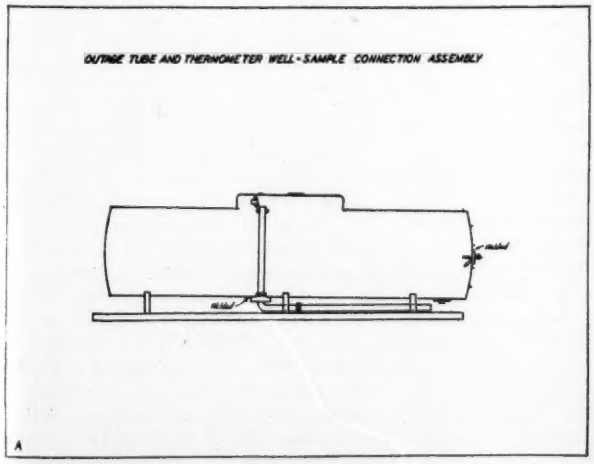
Since natural gasoline has been transported by tank trucks, decided improvements have been made as to losses due to evaporation.

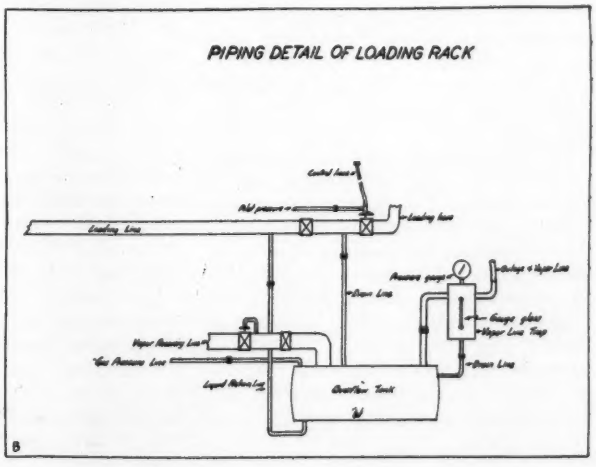
Originally the loading connection was made through the dome and gasoline spilled into the tank from the dome, which caused severe agitation and high evaporation losses. Lengths of hose were then extended to the bottom of the truck tank, which decreased agitation and evaporation losses.

To load by this means each tank truck had to be equipped with special loading heads. Loading racks had to have corresponding connections and overhead loading spouts. Some difficulty was experienced at first due to different designs of loading heads. This was eliminated by a standardization of these heads.

The greatest improvement was made when trucks were loaded from a bottom connection, thus eliminating the necessity of having special heads and bulky overhead loading spouts.

All of these improvements did not





eliminate the possibility of over loading. But did decrease the evaporation losses.

With these conditions in mind the "Truck Gauging Committee" of the California Natural Gasoline Association has investigated various methods and has developed a method and procedure which will eliminate the possibility of these apparent errors in truck loading and gauging.

The equipment before and after loading could be weighed and from the specific gravity of the gasoline its weight per gallon could be determined, thus the actual gallons of gasoline in the tank would be known, regardless if the level was above or below the marker. Each plant manufacturing natural gasoline would have to install expensive scales at the loading rack which eliminated this method from further consideration.

Metering with displacement meters was not deemed advisable, as the volume of vapors for each load would have to be measured and converted to gallons of liquid, to arrive at the net gallons, as the liquid volume indicated by the meter includes liquids that have vaporized.

In a series of checks in which the converted vapor gallons was added to the volume of gasoline loaded, totals corresponded very closely to gauged outages from storage tanks. By using the meter method or replacing the meter with storage tank gauges, loaders would have to make complicatead calculations and corrections, which would require a certain amount of additional training and loading time.

Gauge glasses were then considered, but were not thought advisable from the safety standpoint, as considerable breakage would take place from continual movement of the vehicle. Also gauge glasses would require special calibrations of tanks.

All of these methods are accurate as means of gauging and would assist in locating liquid levels at the marker, but do not provide a method of removing liquids above the marker.

The next method considered by the committee was outage tubes. The outage tube readily provides a method to load exactly to the calibrated marker in the tank and also a means of withdrawiing excess liquids.

By incorporating an outage tube header at the rear and parallel to the loading header of a truck, all hoses and bulky connections are near ground level, thus eliminating the necessity of building loading rack platforms sturdy enough to support piping, etc. In fact it is optional as to the necessity of building loading platforms at all, as ladders are available on trucks and trailers. During the displacement of tank vapors the outage tube acts as a part of the vapor recovery system

As gasoline samples and temperatures are taken from stationary storage tanks, having sample connections and thermometer wells inserted in the shell of the tank, this method is suitable for movable truck tanks. The present practice in sampling gasoline transported by trucks is to get bottle samples and liquid temperatures through the dome hatch after the truck is loaded, or to take the temperature and sample at the loading pump. As a certain amount of vaporization due to agitation and temperature changes take place, samples of this nature do not represent the gasoline in the tank. By the installation of a temperature and sampling device as shown in the slide and since during the loading period the gasoline is in constant circulation, gasoline samples and temperatures will be representative of the gasoline in the tank. This type of connection also provides for the use of the sampling procedure as outlined in the California Natural Gasoline Association "Gauging Bulletin."

As any change in loading procedure would require alterations in tank design, it is felt that the outage tube method and sampling connection will require a minimum expense and equipment lost time to the truck owner. Also in the construction of new truck tanks the outage tube could be returned inside the tank to a flanged outlet at the rear of the truck.

To give the loader positive control over the rate at which he is loading, the manually controlled valve is followed by a pressure actuated valve. It is not necessary for the loader to be on the tank to observe through the look glass when the gasoline is at the marker level, as all overage will drain through the outage tube and will be indicated in the gauge glass attached to the trap in the vapor recovery system. But if it is so desired, by the use of rubber hose of the proper length, attached to the control side of the pressure actuated valve, the loader may observe the marker and outage tube from the tank dome, and by releasing the control pressure, when the gasoline is at the marker or spills over the outage tube, the loading valve will close.

The pressure actuated valve may also be connected to a float device in the vapor recovery line trap, which would automatically close the loading valve when sufficient gasoline has spilled over the outage tube to actuate the float.

The loading rack now consists of a level surface with all piping at ground level, costing less to construct, and from the safety standpoint, less hazardous, due to the elimination of heavy bridges, piping above ground levels, and the necessity of the loader to conduct his operations from both the ground and the top of the tank.

The sample connection provides for accurate temperatures and gasoline samples. The outage tube assures the natural gasoline producer that the load is that as shown by the equipment's certified capacity certificate. Also the producer, trucking company and municipalities are assured that proper vapor space is left in the truck tank as required.

Since the origin of the "Truck Gauging Committee" the scope of the work has been increased to include the gauging and transportation of liquid petroleum gases by tank truck. In a preliminary investigation it has been found that various methods of gauging are in use. Such as rotary gauges, storage tank gauges and slip tubes. Due to the volatility and difficulty in gauging liquid petroleum gases, it will be necessary to enlarge the "Truck Gauging Committee." Men with experience in loading, gauging and familiar with the types of pressure vessels used in the transportation of liquid petroleum gases will be appointed to the committee. With their assistance a bulletin will be compiled acceptable to this branch of the natural gasoline industry.

The bulletin in its final form will consist of recommended construction of tanks for the transportation and gauging of natural gasoline and liquid petroleum gases. The construction and necessary piping of the loading racks. Methods of sampling and gauging. Procedure of loading and unloading. Tables for the correction of liquids to standard conditions and safety precautions to be observed at loading racks and during the transportation of the products.

The Partial Volume and Its Significance

B. H. Sage and W. N. Lacey
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(Continued from Last Issue)

A consideration of Figure 7 indicates that the partial volume of the trap liquid is much smaller than the specific volume of this material and therefore the isobaric, isothermal addition or withdrawal of such relatively non-volatile material from the system does not result in a significant change in its total volume. Likewise it follows that under such conditions the introduction of this material to a system of constant total volume would not result in a large change in pressure.

Applications

The value to the engineer of the partial volume of a component or a constituent rests primarily upon its relation to the specific and total volumes of the

system. The partial volume is related to these quantities by the following general expressions (11):

(10)

$$V = \overline{V}_1 N_1 + \overline{V}_2 N_2 + \ldots\ldots + \overline{V}_n N_n$$

(11)

$$V = \overline{V}_1 m_1 + \overline{V}_2 m_2 + \ldots\ldots + \overline{V}_n m_n$$

These equations indicate that from a knowledge of the relative quantities or the amounts of the components or the constituents present it is possible to ascertain the specific volume or the total volume. Strictly speaking, the partial volume of a component or constituent is a single-valued function of the state of the system. The values of the partial volumes used in these equations must be those for the designated state of the particular system in question. Therefore it remains to establish from experiments the influence of the state of a multicomponent system upon the partial volumes of the components.

Prediction of Volumetric Behavior: At the present time tentative values of the partial volumes of the lighter paraffin hydrocarbons in both the liquid and gas phase are available (2) and (12). These data permit the estimation of the volumetric behavior of multicomponent hydrocarbon systems at pressures up to 3,000 pounds per square inch and the temperature interval between 100° and 160°F except near the critical state for the system. The average uncertainty involved in such predictions is approximately 2 percent although in isolated instances the deviation of the predicted values from those established experimentally may be as great as 4 percent. The methods have already been described in detail and need not be repeated. However, it should be kept in mind that at the present time insufficient experimental background is available to permit the application of such methods to multicomponent systems in the vicinity of the critical state. The method requires detailed information for satisfactory application in this region, for which the prediction of behavior is difficult.

Reservoir Behavior: A petroleum reservoir may be considered to be a system of variable weight such as was described earlier in the present discussion. Assumption of an equilibrium condition is necessary for rigorous treatment. Partial volumes are of value in connection with certain problems relating to reservoir behavior. For example, if it is desired to ascertain the decrease in pressure associated with the withdrawal of one barrel of condensate per acre foot of producing formation from a field employing recycling, the procedure indicated in the accompanying table may be followed. In principle the method requires a knowledge of the composition of the fluids existing within the formation and a knowledge of the pressure-volume-temperature relations of these materials. Figure 8 presents a specific volume-composition diagram for such a material at an assumed subsurface pressure of 4,000 pounds per square inch and a subsurface temperature of 190°F. In this instance the two constituents have been taken as the gas and liquid phases existing in the separator. The material withdrawn from the reservoir is considered to have the composition this liquid phase. In other words, none of the lighter hydrocarbon material associated with the trap liquid is being returned to the formation. The application of Roozeboom's method (5) to the data of Figure 8 at a composoition corresponding to a weight fraction of trap gas of approximately 0.629 which is assumed to correspond to the composition of the well production and of the field yields a value of 0.0143 cubic feet per pound for the partial volume of the trap liquid in this mixture, as is indicated in Table I. From this it follows that the change in volume necessary to maintain the pressure within the reservoir constant is equal to 4.094 cubic feet per barrel of condensate withdrawn. If, on the other hand, it is assumed that the encroachment of water is negligible the reservoir may be treated as an isochoric system. It then follows that the rate of change of pressure with respect to the weight of condensate withdrawn is related to the partial volume and the isothermal compressibility in the following way:

(12)

$$\left(\frac{\delta P}{\delta m}\right)_k^{\overline{V}} = -\frac{\overline{V}\,V_k}{\delta V \over \overline{V}\left(\frac{\delta V}{\delta P}\right)_T}$$

If the corresponding numerical values for these variables are substituted in equation 12 the change in pressure resulting from the withdrawal of one barrel of condensate or separator liquid, from an acre-foot of the formation is found to be 2.96 pounds per square inch. The isothermal compressibility required for the solution in Equation 12 may be obtained by suitable differentiation of the isothermal pressure-volume data. This operation may be conveniently carried out by residual graphical methods. In so far as the experimental results apply to the material existing within the formation and in so far as equilibrium is maintained the results indicated above are descriptive of actuality.

Batch Distillation: The changes within the still of a batch distillation process correspond to a process occurring in an isochoric system of variable weight. This is illustrated in Figure 9. The rate of change in volume of the liquid phase within the still at any particular known concentration may be readily established in the following fashion: From a knowledge of the equilibrium constants for the components, the composition of the gas phase may be ascertained. If the pressure is low the rate of change in the quantity of material present in the gas phase may be neglected. Such simplifying assumptions are not justifiable at high pressures where the specific volumes of the liquid and gas phases are more nearly alike. The weight of component K withdrawn

(Continued on Page 32)

TABLE I

SUMMARY OF CALCULATIONS OF PRESSURE DECLINE IN A CONDENSATE FIELD

Subsurface Pressure	4000 pounds per square inch
Subsurface Temperature	190° F.
Composition Well Production, expressed in weight fraction trap gas	0.628 weight fraction trap gas
Partial Specific Volume trap liquid (from Figure 9)	0.0143 cubic feet per pound
Specific Volume	0.0530 cubic feet per pound
Weight Trap Liquid per barrel of condensate	286.3 pounds
Change in Volume per barrel of condensate	4.094 cubic feet
Isothermal Compressitility	8.0×10^{-6} cubic feet per pound, per pound per square inch
Porosity	0.3 fraction
Connate Water	0.3 fraction
Hydrocarbon voids per acre foot	9147.6 cubic feet
Rate of change of pressure per unit weight trap liquid	0.01035 pounds per square inch, per pound
Rate of change of pressure per barrel of condensate	2.96 pounds per square inch, per barrel

Proposed California Natural Gasoline Association Gas Engine and Compressor Committee Bulletin on Calculating Compressor Horsepower and Capacity

C. N. G. A.
Fall, 1941

Presented by
T. A. Dunlap, Committee Chairman

The Gas Engine and Compressor Committee, organized in 1935, has as its purpose the promotion of agreement and standardization on the problem related to engine and compressor operation in the Natural Gasoline Industry. Its goal has been to assemble data in accurate and usable form, and to present it to the industry as a C. N. G. A. Engine and Compressor Handbook.

The biggest limitation on the committee is that there is seldom any necessity of agreement on engine-compressor problems among the various companies involved. In that respect this committee differs from the other C. N. G. A. committees in that there has been no direct economic force **requiring** agreement as there has been in Gas Measuring, Gas and Gasoline Testing, Gauging, etc. However, there is upwards of $20,000,000 worth of engine-compressor horsepower operating in the plants of the industry. This equipment costs more than $5,000,000 a year to operate. Maintenance charges run in the order of $1,000,000 per year. With this amount of money at stake it is logical that improvement of operation will make large savings to the industry. It is to this end that the Gas Engine and Compressor Committee are working.

The field, however, is large and indefinite. Items that should be included in a C. N. G. A. Handbook are: Standardized compressor horsepower and capacity calculations, standardized nomenclature, standard means of engine classification, the best practices with respect to engine and compressor installation, operation and maintenance, etc. Because a handbook on all the above subjects is still a long way from completion, this committee and the Technical Committee have adopted the plan of presenting bulletins covering one subject at a time. The first of these will be the proposed bulletin that the Gas Engine and Compressor Committee has been asked to preview for you gentlemen today. That bulletin deals with the problem of compressor horsepower and capacity, since this is the most vital subject coming under the jurisdiction of the committee.

The intent of this publication is to provide the means of calculating the amount of gas that a compressor cylinder will handle under given conditions of pressure and temperature, and the horsepower that is required to compress that gas. The basis of the data presented is the work that the Committee did in 1935-36 while Lyman Scheel was chairman. This experimental work was done at Dominguez on dry gas at pressures up to 300 lbs. per sq. in., and with ratios of compression up to ten. The present committee has done no original experimental work, but based on operating experience it has taken the Dominguez tests and defined certain boundary limits where the data is accurate to a plus or minus 5% degree. This limit is chosen because the committee's experience has indicated that the errors involved in surge losses or gains, in valve and ring losses, and in measurement of clearance, pressure, temperature and speed make it impractical to expect closer agreement than plus 0, minus 5%. However, the committee emphasizes that, by exercising the proper care, this limit need not be exceeded.

It is important that this bulletin should not be interpreted as presenting the exact final word in compressor calculation. Actually, it is the present data used in the industry, and experience has shown that within the boundary limits here-in prescribed the results obtained will be accurate to the degree necessary for satisfactory operation.

The boundary conditions are as follows:

1. The data are limited to use on comparatively dry gas—gravities of 0.6 to 0.85.
2. The data are limited to relatively "cool" gas—intake temperatures of 60°F. to 100°F.
3. The data are limited to ratios of compression of 4 or less.
4. The data are limited to pressures up to 500 lbs. per sq. in.

By way of explaining these limitations slide No. 1 has been prepared. Indicator cards taken recently on a 6 x 12 cylinder operating at 300 R. P.M. have here been re-plotted. Card No. 1 shows an actual trimmed card in a case where three of the above mentioned boundary conditions have been exceeded: the card shows a ratio of compression of 6.8, an intake temperature of 163°F., and a gravity of 1.45. Card No. 2 shows the theoretical card that would be expected assuming that the C. N. G. A. data held for these conditions. The very obvious lack of agreement is in large part explained by comparing the volumetric efficiencies in the two cases. The scaled volumetric efficiency of 17.4% for card No. 1 agrees fairly well with the 18.6% figure obtained from the metered capacity, but had the calculated efficiency of 41.5% been used for computing the cylinder capacity, the result would have been 55% in error.

This extreme case points out the

FIG. I

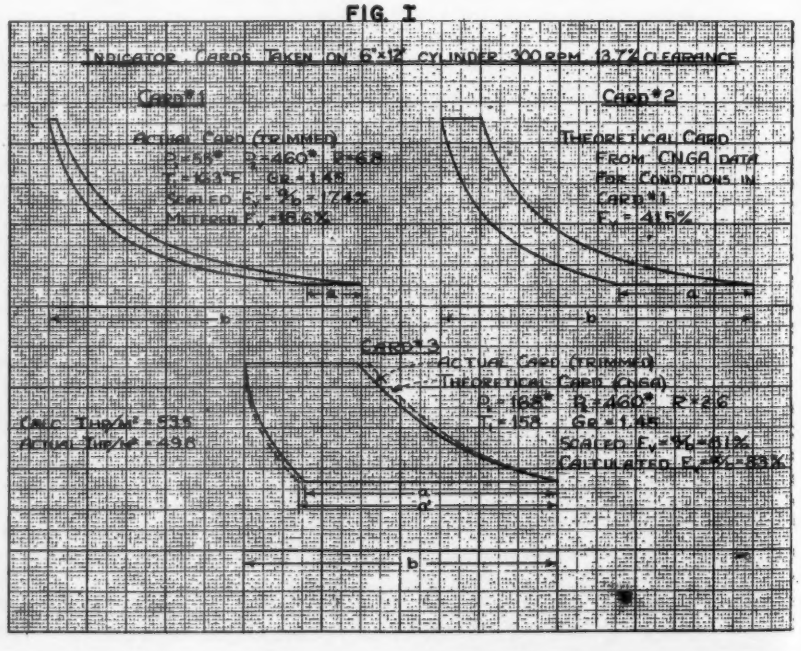


FIG. II

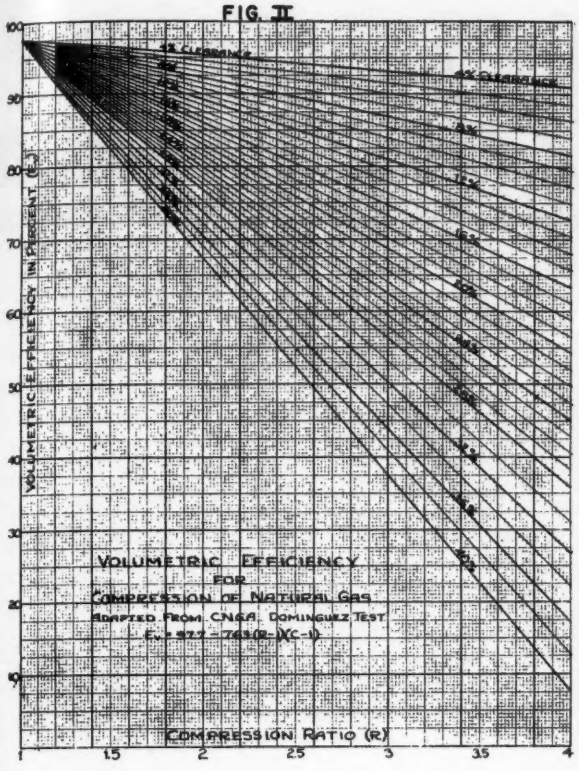
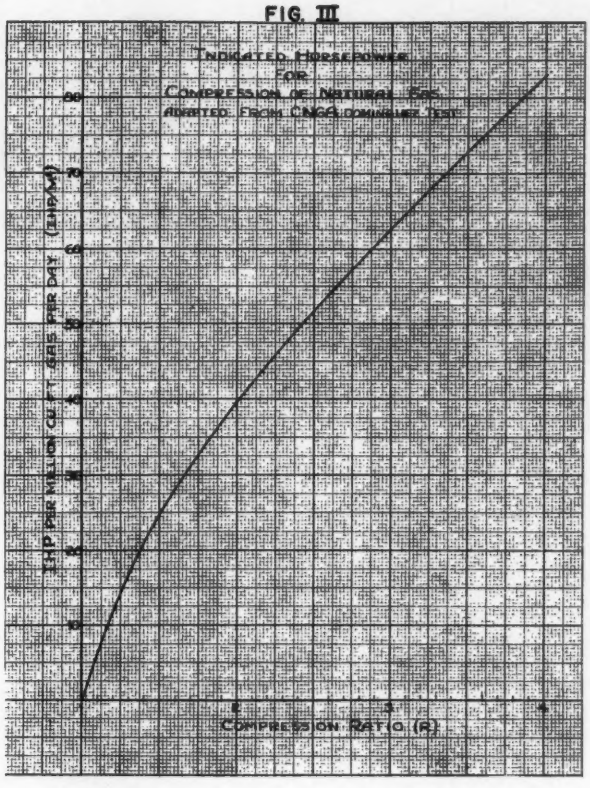


FIG. III


INDICATED HORSEPOWER
FOR
COMPRESSION OF NATURAL GAS
ADAPTED FROM CNGA DOMINGUEZ TEST
IHP PER MILLION CU FT GAS PER DAY (IHP/M)
COMPRESSION RATIO (R)

necessity of boundary limits when using our data. In this case the combination of high "R", high gravity, and high intake temperature created a condition that is outside the scope of any data that the C. N. G. A. has on hand. The committee is seeking means of enlarging its fund of information so that reasonably accurate calculations may be made over a larger range of conditions, but the committee also feels that the most adequate answer to such problems is illustrated by card No. 3 on Fig. I. Here, by means of two-staging, gas at the same gravity and approximately the same intake temperature as in card No. 1 is compressed at an "R" of 2.6. The solid lines indicate the actual trimmed card. The dotted lines indicate the expected theoretical card, based on C. N. G. A. data. The scaled volumetric efficiency is 81% and the calculated value is 83%—a difference of approximately 2.5%. The calculated 53.5 Indicated Horsepower per Million rate is 7.2% higher than the actual 49.8 value. It should be pointed out that this is a comparison of trimmed card horsepower—presented to illustrate a point. The inclusion of valve and surge losses would further affect the calculation.

In other words, although the values of gravity and intake temperature in this example are beyond the limits set up by the committee, the 55% error in the capacity calculation in card No. 1 is reduced to 2.5% simply by reducing the "R" from 6.8 to 2.6. The horsepower error is reduced a similar amount, but the final error of 7.2% is beyond the 5% allowable set up by the committee, which explains the need of the temperature and gravity limits in conjunction with the ratio of compression limit when using the data here-in presented for capacity and horsepower calculations.

The boundary limits outlined above, then, serve two purposes. The first is an acknowledgment of lack of complete

---

FIG. IV

NOMENCLATURE:

D = Cylinder diameter in inches.
d = Piston rod diameter in inches.
A = Effective piston area in square inches.
a = Piston rod area in square inches.
L = Length of stroke in inches.
Disp. = Cylinder displacement in thousands of cubic feet per day at N_b.
P_1 = Cylinder intake pressure in lbs./sq.in., absolute.
P_2 = Cylinder discharge pressure in lbs./sq.in., absolute.
P_b = Pressure base = 14.73 lbs./sq.in., absolute.
N = Compressor revolutions per minute.
N_b = Base RPM = 100 RPM for included tables.
T_b = Temperature base = 60°F. = 520°F., absolute.
T_1 = Intake temperature, absolute. (°F. plus 460).
T_2 = Discharge temperature, absolute. (°F. plus 460).
C = Cylinder clearance in percent of piston displacement.
E_v = Volumetric efficiency in percent.
R = Ratio of Compression = P_2/P_1.
Mcf/day = Thousands of cubic feet per day at P_b and T_b.
IHP/M = Indicated compressor horsepower per million cubic feet of gas per day.
E_m = Mechanical efficiency.

$$n = \text{Ratio of specific heats} = \frac{\text{Sp. Ht. at const. press.}}{\text{Sp. Ht. at const. volume}} = \frac{C_p}{C_v}$$

BHP = Brake Horsepower. (HP required at shaft of driving unit).

CAPACITY CALCULATION:

$$\text{Mcf/day} = \text{Disp.} \times \frac{P_1}{P_b} \times \frac{N}{N_b} \times \frac{T_b}{T_1} \times E_v = 0.353 \times \frac{\text{Disp.} \times P_1 \times N \times E_v}{T_1}$$

HORSEPOWER CALCULATION:

$$\text{BHP} = \text{IHP/M} \times \text{Mcf/day} \times \frac{T_1}{520} \times \frac{1}{E_m}$$

(Continued on Page 30)

Field Development

Los Angeles Basin

Basin Finishes Potrero No. 11

Basin Oil Co., most successful operator in the small Potrero field, recently completed its No. 11 well on the Country Club property south and east of the intersection of Manchester and Prairie streets. Adequate production was not found in the first hole drilled to 3899 ft. so a whipstock was set at 2500 ft. and the well redrilled to 3891 ft. where casing was cemented and gun perforated in a short interval below 3700 ft. Brought in on gas lift, production is approximately 100 bbls. a day of 49 gravity clean oil.

A dismal financial failure when first discovered nearly 15 years ago, Potrero is now an outstanding example of what modern engineering technique can do. Located on the Inglewood fault, the complexities of the field completely baffled early operators, only a few of whom were lucky enough to get commercial wells and it was not until three years ago when Basin Oil Co. began its development program that any real success was attained. Starting with the comparatively meager knowledge gained from the early operations, Basin has used practically everything in the book including electric logging, core analysis, rate of penetration logs and directional drilling to put the once dead field really back on the map.

Following the technique used by Basin Oil Co., several other operators have obtained satisfactory wells, the latest of which was G. E. Hutchinson's Inglewood No. 1, reported to be pumping about 50 bbls. daily.

Five Points Well Pumps 100 Bbl. Rate

Pumping at a 100 bbl. a day rate, Marfar Oil Co. brought in Greer No. 1 as a westerly outpost in the tiny Five Points area south and east of the corner of Huntington Beach Blvd. and Ellis St. at Huntington Beach. The oil tests about 17 gravity and is very nearly free of water.

Considering the yield obtained, drilling at Five Points is remarkably cheap, the Marfar well, for example, requiring only a few days to make the 4233 ft. of hole. A single string of casing was set, that being 5¼ in. with 39 ft. of 120 mesh perforated landed on bottom and cemented through perforations at 4190 ft. above the oil zone and at 1100 ft. to protect surface waters.

LOS ANGELES BASIN WILDCATS

Area	Well	No.	Section	Depth	Status
Athens	Rankin & Williams	1	7, 3-13	9483	Idle
Castaic	O'Dell, A. J.	1	9, 4-17		Grading
	Young, Roy, W., Inc., Walker	1	11, 4-16	6595	Drilling
	The Texas Co., Fernando	1	11, 4-17	5989	Drilling
Newhall	Airline Oil Co., Perkins	1	11, 3-16	200	Idle
	Aztec Oil Co., Sanborn	1	6, 3-16	6113	Idle
	Barnsdall Oil Co., Limbocher	1	17, 3-16	5239	Drilling
	Rankin & Norell, Ferguson	1	31, 4-16		Rig
	Willis & Assoc., Ferguson	1	30, 6-17	2824	Drilling
Palos Verdes	Newton Dev. Co., Palos Verdes	1	13, 5-15	4500	Abandoned
	Surety Holding Co.	1	22, 5-14	1105	Drilling
Puente Hills	Axis Pet. Co., Tandberg	1	13, 2-11		Foundation
	Continental Oil Co., Turnbull Comm.	2	13, 2-11	1165	Drilling
	Sunset Oil Co., Baldwin	1	11, 2-11	4681	Idle
Rio Hondo	Potrero Oil Co., Well	1	32, 1-11	2183	Drilling
San Fernando	Fernando Oils, Ltd., Chatsworth	1	18, 2-16		Location
	Shell Oil Co., Mission	2-1	25, 3-16	1730	Drilling
	Tide Water Assoc., Mission	1	26, 3-16	7678	Drilling
	Tide Water Assoc., Sesnon	1	28, 3-16		Location
Whittier La Habra	Fullerton Oil Co., La Habra	9	25, 2-11	2453	Idle
	Los Nietos Valley Oil Co., Woodard	1	29, 2-11		Rigged up
	Union Oil Co., Sansinena	13	30, 2-10	3378	Drilling
	Orange County				
Anaheim	The Texas Co., Spencer	1	1, 4-11	7151	Drilling
Bolsa Chica	La Bolsa Ro. and Synd., Well	1	22, 5-11		Rigged up
Costa Mesa	Thompson, Milton N., Banning	1	9, 6-10	5649	Fishing D.P.
Kraemer	Atlas Oil Co., Kraemer	1	36, 3-9	320	Drilling
	San Bernardino County				
Chino	Prado Oil Corp., Lamp	1	32, 2-7	1733	Idle

In the Old Field, West American Oil Co. is completing Ashton No. 9 after gun perforating casing cemented on bottom at 4553 ft. and is moving the derrick and equipment to the location for No. 10. Adjoining the property, Tide Water Associated Oil Co. is redrilling the old Miley-Keck No. 10 originally drilled by Amalgamated Oil Co. After skidding the rig a few feet from the location of the old Brooks No. 5, Harold C. Morton is drilling No. 5-A.

One block south of the old sugar refinery, Holly Development Co. is redrilling Turley No. 2 while to the east, Beloil Corp. is nearly ready to recomplete Davenport No. 6 after redrilling from a shallow depth.

Southwest Exploration Co. is below 3300 ft. in its No. 44 being whipstocked under the State Tidelands from Standard Oil Co. property on Ocean Blvd. Southwest's last completion, No. 43, established a potential of over 900 bbls. a day.

Newton Abandons Cliff Top Wildcat

The Los Angeles Basin's only recent deep cable drilled wildcat was abandoned by Newton Development Co. Located at the crest of a 70 ft. cliff overlooking the ocean at the southwest tip of Palos Verdes Hills, the hole was carried to 4500 ft. bottoming in schist the top of which was reported at 3900 ft. The drilling equipment used was of a modern type powered with a heavy duty single cylinder diesel engine.

Western Gulf Completes Deep Oak Canyon Well

Extending Oak Canyon deep production nearly half a mile to the south from the discovery well, Lechler No. 2, Western Gulf Oil Co. completed Wickham No. 1 as the second lower zone well in the new field. On first gauges, production varied from 19 to 30 bbls. an hour of clean 33 gravity oil through restricted orifices while the gas yield approximated 500 cu. ft. per bbl.

Departing from the procedure used in completing its first deep well, Western Gulf cemented 7 in. casing on bottom at 7437 ft. in the Wickham project and gun perforated the intervals 7340-7390 ft. and 7272-7288 ft. Kern Drilling Co., contractor, has moved drilling equipment and is preparing to spud Lechler No. 3 west of the new producer.

Hathaway Co.'s Ram No. 2, located southwest of the Western Gulf operations, is still endeavoring to complete in the shallow zone at 2700 ft. after plugging bottom from 8100 ft.

The Oak Canyon field is located in sec. 31,5n-17w in the Castaic area.

Dominguez Outpost Finds 8th Oil Sand

Coring Eighth Callender Zone oil sand from 7708 to 7740 ft., Decker-Osbourne & Associates Froom No. 1 has again brought the extreme west end of Dominguez to the at-

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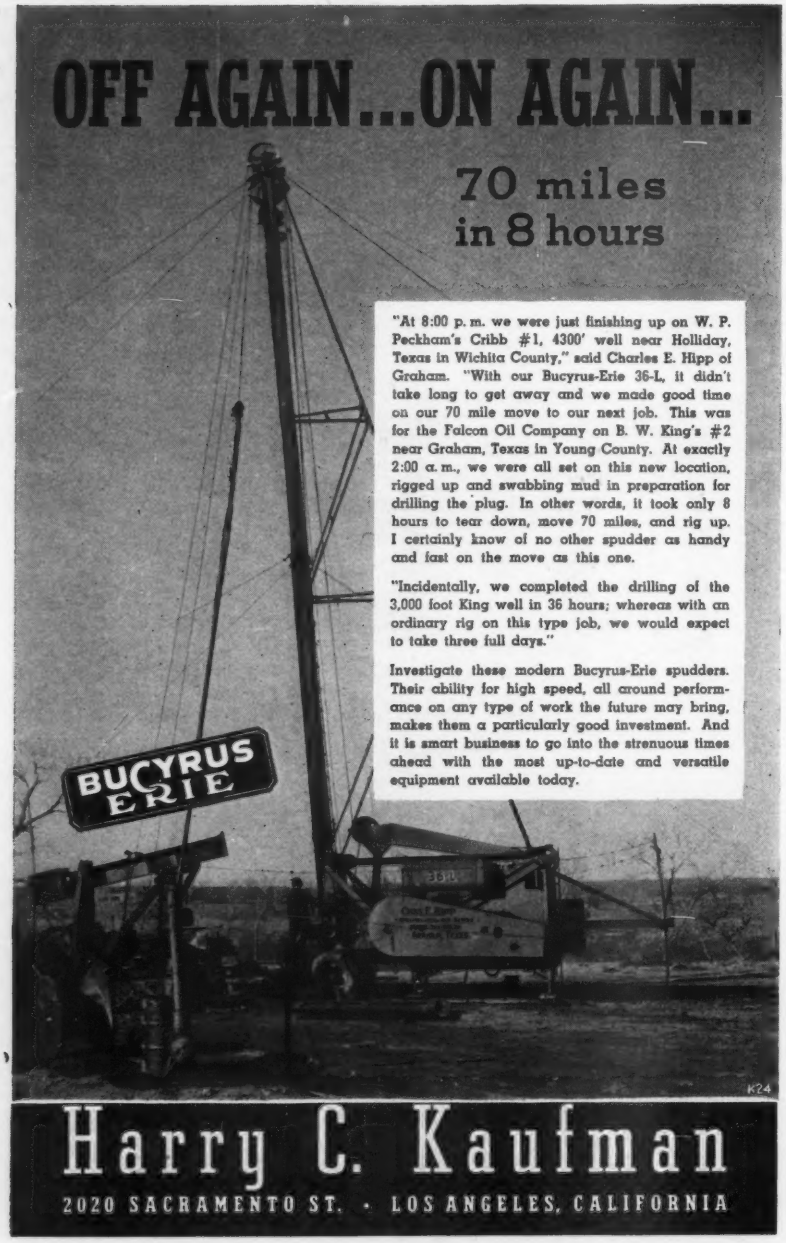
OFF AGAIN...ON AGAIN...
70 miles
in 8 hours
"At 8:00 p. m. we were just finishing up on W. P. Peckham's Cribb #1, 4300' well near Holliday, Texas in Wichita County," said Charles E. Hipp of Graham. "With our Bucyrus-Erie 36-I, it didn't take long to get away and we made good time on our 70 mile move to our next job. This was for the Falcon Oil Company on B. W. King's #2 near Graham, Texas in Young County. At exactly 2:00 a. m., we were all set on this new location, rigged up and swabbing mud in preparation for drilling the plug. In other words, it took only 8 hours to tear down, move 70 miles, and rig up. I certainly know of no other spudder as handy and fast on the move as this one.
"Incidentally, we completed the drilling of the 3,000 foot King well in 36 hours; whereas with an ordinary rig on this type job, we would expect to take three full days."
Investigate these modern Bucyrus-Erie spudders. Their ability for high speed, all around performance on any type of work the future may bring, makes them a particularly good investment. And it is smart business to go into the strenuous times ahead with the most up-to-date and versatile equipment available today.
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tention of Los Angeles Basin oil men. Opinions differ as to the ability of the sand to produce commercially, but the 32 ft. interval now open is at least good enough to justify a production test and the operators are preparing to set a combination liner for the try.

The Froom well is located south of Artesia Blvd. and east of Main St. and is just outside the limits of the Seventh Zone production developed in wells to the north and east this year. In both directions, the Eighth Zone had been found barren, indicating the new accumulation may be the result of cross faulting at the southwest corner of the field.

Other activity in the westerly portion of Dominguez is confined to the redrill jobs caused by the collapse of casing during the recent earthquake. Of these, Union Oil Co. is working on seven wells and R. E. Havenstrite, Operator, is nearly ready to recomplete Larronde No. 4.

In the central section, Shell Oil Co. is drilling Reyes No. 128 below 4900 ft.

Bartholomae Completes East Coyote Project

With bottom at 6900 ft. in the so-called Riley sand, Bartholomae Oil Corp. is completing its Stern No. 11 in the deep zone at the west end of the East Coyote field. Production is expected to equal the 500 bbl. average of the other wells in the area.

Failing in an attempt to find a deeper sand in the old central portion of East Coyote, Graham & Loftus Oil Corp. plugged Perkins No. 2 from 4687 ft. to 3590 ft. and is preparing to test the old zones.

Aliso Canyon Area Reports New Activity

The location of a new prospect well and the resumption of work on an old hole by a new operator highlight the news from Aliso Canyon where two wildcats and a deep test are already attracting attention.

The new exploratory project, a joint venture of Tide Water Associated Oil Co. and Standard Oil Co., will be located in sec. 28,3n-16w half a mile due west of Tide Water Associated's Porter No. 26 which is currently making a deep test as the westerly outpost to shallow zone production in the Aliso Canyon field. The new well will be known as Sesnon No. 1 and is said to have the Aliso deep zone as its objective.

Believing the faulting which cut off upper zone production in the Standard Oil Co. H. R. Ward No. 1 may not extend to the 8000 ft. horizon, Universal Consolidated Oil Co. is preparing to deepen the 6909 ft. abandoned hole. Ward No. 1, a direct offset to production on the Porter lease to the south, was drilled and abandoned by Standard before the deep zone discovery.

Porter No. 26, now drilling below 7550 ft., found the Porter Zone unattractive and was chosen by Tide Water Associated Oil Co. to be the second well to seek the high pressure gas and condensate sand found

in Porter No. 12 in a higher structural position.

The two wildcats located east of Aliso Canyon, Tide Water's Mission No. 1 in sec. 26 and Shell Oil Co.'s Mission No. 2-1 in sec. 25, are drilling ahead at 7680 ft. and 1850 ft. respectively.

Anaheim Wildcat At Critical Stage

Last reported as spot coring at 7175 ft., The Texas Co.'s Spencer No. 1 is nearing the depth at which showings, if any, will be found. The well is located near Highway 101 between Anaheim and Buena Park.

Havenstrite Completes New Del Valle Project

R. E. Havenstrite, Operator, is completing Leibhart No. 1, easterly Del Valle outpost, in the Del Valle zone at 6795 ft. Casing was cemented at the top of the sand at 6545 ft. and a perforated liner was landed on bottom.

The Havenstrite interests are drilling Nos. 9 and 10 on the Lincoln property in the discovery area while Herley-Kelley, Standard Oil Co. and Ohio Oil Co. are drilling one each in the westerly section of the field. Bankline Oil Co. is grading location for Handy No. 101.

Inglewood Well Flows 1150 Rate

Flowing at an initial rate of 1150 bbls. a day, Tide Water Associated Oil Co. brought in Vickers No. 72 as the latest producer in the Inglewood deep zone. With the bean reduced to 8/64 in., production was 443 bbls. of 35 gravity oil cutting 4.0 percent. The water string was cemented at 7753 ft. and a liner containing 426 ft. perforated was landed on bottom at 8320 ft.

Next well scheduled for completion is Hogan Petroleum Co.'s Machado No. 4-A which is drilling "in" after cementing casing at 7820 ft. Texas Co.'s jinx well, R. C. Smith No. 8, has casing cemented over the sand and should follow the Hogan well on production.

Brookner Abandons Montebello Test

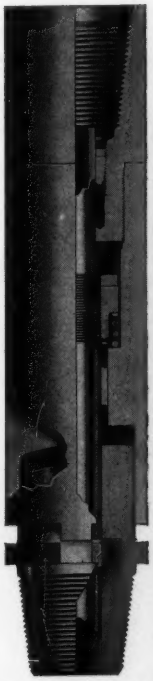
Brookner Oil Co. abandoned its Montebello south edge well at 4191 ft. when only poor sands were found in the upper zones.

J. P. Getty Tests Deep Athens Well

With the hole bottomed at 8100 ft. and a 5½ in. combination string cemented at 7765 ft., the top of the perforated interval, J. Paul Getty is testing his Athens No. 2-12 at the corner of 124th St. and Hoover St.

In the Rosecrans section, Barnsdall Oil Co. is drilling O'Dea No. 21 at 7951 ft. and Trust No. 7 at 7100 ft.

WHAT'S UP?



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Castaic Wildcat Test Recovers Salt Water

The Texas Co.'s Fernando No. 1, located in sec. 11,4n-17w north and east of the Del Valle field, is coring below 6000 ft. after making a formation test 5675-5875 ft. which recovered 39 stands of mud and water testing 800 grains of salt per gallon. The well is not yet too low to encounter production and is being closely watched for new developments.

Four Wells Finished At Wilmington-Torrance

Four good producers were added to the group of wells centering about the intersection of Figueroa St. and Pacific Coast Highway during the past fortnight. Most northerly well was Bristol Oil Corp.'s Spring No. 1 at the corner of "R" St. and Figueroa which, bottomed at 3732 ft., came in pumping 140 bbls. daily of 17.4 gravity oil with a cut of 5.0 percent. One block to the south, Westport Oil Co. finished W. P. No. 7 at 3761 ft. for 136 bbls. with a relatively high percentage of mud and water.

South of Pacific Coast Highway and west of Figueroa St., Los Feliz Oil Co. brought in Capital No. 1 at an initial rate of 130 bbls. a day cutting 7.0 percent. Delayed by a minor blowout after running the liner, Los Angeles Basin Petroleum Corp.'s Phillips No. 3 was just getting on production at press time. The hole is bottomed at 3743 ft. and is open below 3150 ft.

Standard Completes Third Los Flores Well

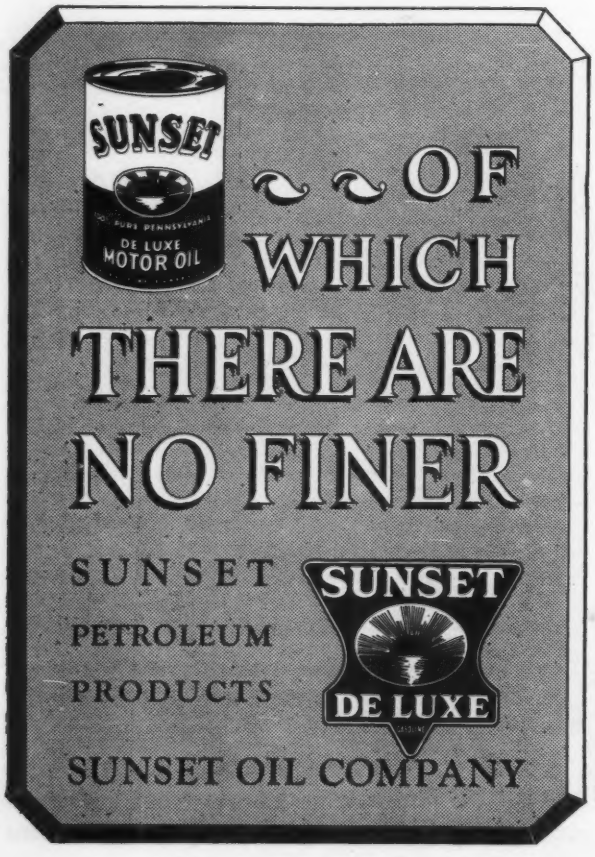
Further proving the value of the Monterey production in the West Cat Canyon area, Standard Oil Co. brought in Los Flores No. 3 for 850 bbls. a day on agitated flow. When shut in after seven days, production was 1009 bbls. a day of 14.5 gravity clean oil. Situated one location south and west of the center of sec. 27, 9n-33w, the well was bottomed at 6100 ft. and finished with 7-in. casing cemented at 5545 ft. Top of the Miocene was placed at approximately 5000 ft.

In the east half of the same section, Union Oil Co. is drilling Bell No. 12 and has derrick up for No. 13. Standard Oil Co.'s Los Flores No. 4 is making hole below 2500 ft.

Two Wells Drill In Newhall Area

Seeking a new field southeast of Newhall-Potrero, C. G. Willis & Associates are drilling near the 3000 ft. level in sec. 36,4n-17w on Ferguson property. Objective of the test is the Upper Modelo in which three sands are productive in the nearby field.

Still finding the going slow, Barnsdall, Bandini and Ambassador companies are drilling below 5000 ft. in Limbocker No. 1 in Towsley Canyon.



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THIS LAUGH

OFF!!

From the chief clerk of the company which built the first crude oil pipe line to the eastern seaboard comes this bit of Yuletide thought.

Mr. and Mrs. Dohe, aged about 45, were discussing what they would like to have for Christmas. Mrs. Dohe wanted a new car and Mr. Dohe would be pleased with a new Hamilton wrist watch. Christmas morning at the tree she unwrapped a beautiful package which contained a gorgeous silk nitie instead of keys to a new car, and she threw it on the floor in disgust and went in to breakfast. When he opened his package he was disappointed to find a new pair of trousers and not a new watch, and he gave them a toss, they hung on the chandelier, and he stalked off to breakfast. When the maid came in to serve she lifted Mrs. Dohe's plate and beneath it were the keys to a new Packard, and under Mr. Dohe's plate was a beautiful Hamilton wrist watch. Very much ashamed at their display of temper they embraced and went back to the tree. He took down his trousers and she picked up her nitie and they had a real old-fashioned Christmas after all.

Geo. Tyler contributes this one:

"The jungle was all around us. Ammunition, food, and whiskey had run out, and we were parched with thirst!"

"But, wasn't there any water?"

"Sure. But it was no time to think of cleanliness."

Then, there's **Bill Beck's** story about the farmer who made a nice deal on his load of produce in the city, and decided to surprise his wife by returning home in a new suit of clothes, the first in 15 years. After the momentous purchase, which included new shoes and hat, he set out for home. At a short distance from his farm he drove off the road to a sheltered bend in a river, where he proceded to take off his old clothes and toss them in the swiftly moving water. The last garment had swirled from sight when it suddenly came to him that he had forgotten to take the new clothes from the store.. For a moment he remained deep in thought, then, stepping into his wagon, he said: "Giddap, Maud, we'll surprise her anyhow!"

And **Tom Taggart** recalls this one: Examining army doctor, to recruit:

"How are your bowels?"

Rookie: "They didn't issue me none."

Doctor: "I mean, are you constipated?"

Rookie: "Naw, I enlisted."

Doctor (exasperated): "What's the matter with you. Don't you know the King's English?"

Rookie: "They tell me he is, but I ain't sure."

"What does this expression 'Sezz you' mean?" asked the judge.

The clerk of the court replied: "My lord, it appears that this is a slang expression of American origin which has gained regrettable currency in the language of our people through the insidious agency of the cinema, and is, I am led to understand, employed to indicate a stage of dubiety in the mind of the speaker as to the veracity, or credibility of a statement made to him."

"O yeah!" responded the judge.

Names used on this page are entirely fictitious, and any resemblance to persons either living or dead is purely coincidental.

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San Joaquin Valley

Amerada Testing Riverdale Wildcat

Tests to try the productivity of the Riverdale area, midway between the towns of Hanford and Helm in Fresno county, are under way in Amerada Petroleum Corp.'s Lawton No. 45-26.

Located near the center of sec. 26,17s-19e, the well bottomed in Siltstone at 8311 ft. after topping the Temblor at 5615 ft., the Kreyenhagen at 7610 ft. and the Eocene at 7900 ft.

A string of 5½ in. casing cemented at 8116 ft. and cleaned out to 8063 ft. was gun perforated from 7990 to 8010 ft. where swab tests recovered only salt water, a recovery consistent with the expectations concerning the Eocene possibilities at this point.

At last report the well was being plugged higher for further trials. Best showings in the well are reported to be in the approximate interval 6700 to 6800 ft.

Wilshire Annex Spuds Second Jacalitos Well

Wilshire Annex Oil Co. is drilling its second Jacalitos area well, No. 21-26E, a short distance north and west of its discovery Well No. 33-26E near the center of sec. 26, 21-15 in Fresno county.

Last reported at 1445 ft., the well seeks to extend production found in the Temblor by the original well. Utilizing only 20 ft. of zone from 3885 to 3905 ft. the discovery well pumped 100 bbls. of clean 40 gravity oil per day.

B. V. Hills Deep Well Completed as Gasser

Honolulu Oil Corp.'s No. 25-P, world's second deepest well located atop the Buena Vista Hills, is completed as a comparatively small gasser.

After reaching 14,622 ft., where mechanical difficulties necessitated a shut down on hole making, the well was patiently tested uphole without conspicuous success to the final plug at 2656 ft. Gun perforated in the interval 1755 to 1685 ft., the well initialed gas at a 500,000 cu. ft. rate. Now shut in under a balanced 250 lbs., the highest rate was measured at 1,729,000 cu. ft. on open flow with 95 lbs. tubing pressure and 150 lbs. casing pressure.

Richfield Locates Kerman Area Wildcat

Anticipating an early spring drilling in the Kerman area, Richfield Oil Corp. has released location for a wildcat to be called Ponte No. 1.

Intended as a thorough test of the area, the well will be drilled approximately 1650 ft. south and 990 ft. east of the northwest corner of sec. 30,13-17.

Raisin City Outpost Wet on Formation Test

Barnsdall Oil Co.'s Ripperdan No. 71-24, southwesterly outpost of the Raisin City field located in sec. 24, 15-17, recovered only saltwater on a formation test of the Seaboard 88 sands, entered at 5126 ft.

Bottomed at 5161 ft. in siltstone, the well was tried in the interval 5126 to 5158 ft. and after the saline

SAN JOAQUIN VALLEY WILDCATS

Area	Well	No.	Section	Depth	Status
	Fresno County				
Helm	Amerada Pet. Co., Wyant	5–27	27, 16-17	3961	Drilling
	General Pet. Corp., Esperoad	75–33	33, 16-17		Rig
Jacalitos Hills	Wilshire Annex Oil Co.	21-26E	26, 3-15	1445	Drilling
Kerman	Richfield Oil Corp., Ponte	1	30, 13-17		Location
Raisin City	Barnsdall Oil Co., Ripperdan	1	24, 15-17	5161	Testing
	Seaboard-T.W.A.-Union, S.T.U. 66–13		13, 15-17	4990	Drilling
	Shell Oil Co., Inc., Prop. Inc.	7–18	18, 15-18	988	Drilling
Riverdale	Amerada Pet. Corp., Lawton	45–26	26, 17-19	8311	Testing
	Kern County				
Arvin	Pacific Western, Geo. F. Getty, Inc. Houchin	1	27, 31-29	2070	Drilling
Belridge—South	Ivy Drilling Co., Parkford	1	12, 29-21	1140	Bailing
	Sentinel Oil Co.	1	10, 28-20	3902	Idle
Edison	Getty, J. Paul, Portals Corp.	1	5, 30-29	2310	Drilling
Grapevine	Kern Line Oil Co.	1	19, 11-19	8390	Idle
McClung	Macrate, A. N., Haberfelde	1	32, 29-26	12025	Fishing, D.P.
Mt. Poso	Alpha Oil Co., C. V. Elliott	1	1, 27-28	1027	Idle
	Bishop, Bradford	1	22, 27-28	1432	Completed
Paloma	General Pet. Corp., Gallagher	61–33	33, 31-26		Grading
	Western Gulf Oil Co., L.A.A.C.	16–6	6, 32-27		Rig
	Western Gulf Oil Co., Symons	12–7	7, 32-27	11700	Stdg. cem.
Richgrove	Bolling, R. S. Quinn	3	15, 25-27	2397	Drilling
	Shell Oil Co., Smith Cairns	3	11, 26-27		Foundation
Shafter	Continental Oil Co., Neuman	1	36, 27-24		Rigging up
	General Pet. Corp., S.P.	51–15	15, 28-24	13012	Drilling
Shale Hills	The Texas Co., Anderson, Inc.	1	19, 28-20	5777	Fishing
	Tideland Oil Co., Grant Est.	1	4, 27-18	2596	Drilling
Union Avenue	Hancock Oil Co., Roberts	3	6, 30-28	4241	Producing gas
	Hancock Oil Co., Roberts	4	6, 30-28	765	Drilling
	Richfield Oil Corp., Union Ave.	2	6, 30-28	2996	Drilling
	Kings County				
Kettleman Hills	Mid-Kettleman Co., Bunting	1	25, 23-18	9138	Idle
Pyramid Hills	Pacific O. & G. Dev. Corp., West Slope	2	20, 24-18		Location
	Tulare County				
Kingsburg	Goble, W. E., Goble	1	28, 16-23	1496	Drilling
Terra Bella	Stout, Geo. W., Stout	2	11, 23-27	745	Cleaning out
Tipton	Richfield Oil Corp., Hewitt	1	1, 21-25		Location
Trico	Trico Oil & Gas Co., Seymour-Bolz	1	20, 24-23	2469	Comp. gasser
	Trico Oil & Gas Co., Lee	1	17, 24-23		Foundation

recovery was plugged to 5140 ft. for tests of the upper zones.

At the northwest flank of the new field the Seaboard Oil Corp., Tide Water Associated and Union Oil Co.'s latest joint well, S.T.U. No. 66-13 in sec. 13,15-17, is reported in gray sand and shale at 4990 ft. after finding the top of the Shell sand at 4978 ft.

In the main section of the field, Shell Oil Co., Inc. is drilling Properties, Inc. No. 7-18, sec. 18,15-18 at only a 1000 ft.

Amerada Drilling New Helm Project

A half mile northwest of the company's discovery well in the Helm area, Amerada Petroleum Corp. is near 4000 ft. with Weyant No. 5-27 in sec. 27, 16-17.

The well seeks to extend the producing area discovered by Clover No. 31-34 in October of this year. Now shut in, the Clover well was proved producible in two Miocene intervals and also in one section of the Eocene. Utilizing only the upper zone near 7300 ft. the well yielded a 13,618,000 cu. ft. gas flow and 64 gravity condensate at a 662-bbl. per day rate.

Moving a half mile southwest of discovery, General Petroleum Corp. has built rig for Esperoad No. 75-33 in sec. 33, 16-17.

With drilling moving well out on both ends of what appears to be the structure, the current drilling should add much to knowledge of this new Fresno county field.

Mount Poso Outpost Makes Good Producer

Bradford Bishop and the Signal Oil & Gas Co. have completed Well No. 1, east of the Mount Poso field, as a substantial pumper.

Located in sec. 22, 27-28, the well was bottomed at 1433 ft., and 6⅝-in. casing cemented over the Vedder at 1418 ft. With 4¾-in. liner containing only 10 ft. of perforation landed on bottom, the well was completed pumping 100 bbls. of 15.8 gravity oil cutting 26.0 per cent sand.

After cleaning out the free sand the well was put back on the beam for 260 bbls. of clean production. With the pump slowed to 8 strokes per minute the well is currently making 125 bbls. of 15.8 gravity oil cutting only 1.5 per cent.

Drilled in the belief that a fault accumulation existed at this location, the well has apparently confirmed another of the small but profitable accumulations characteristic of the eastside fields.

Pac. Western-Getty Drilling Arvin Try

Pacific Western Oil Corp. and Geo. F. Getty, Inc., are drilling Houchin No. 1 at 2070 ft. Located in sec. 27, 31-29 south of the main Arvin field, the well is an offset to production found by General Petroleum Corp. during 1937.

Now owned by Wood-Callahan, the discovery, and sole producer, was finished flowing 120 bbls. of 29.7 gravity clean oil.

Richfield Plans Tipton Wildcat

Richfield Oil Corp. has located Hewitt No. 1 for immediate drilling 330 ft. south and 330 ft. east of the west quarter corner of sec. 1, 21-25 in the Tipton area of Tulare county.

Trico O. & G. Finishes Trico Field Gas Well

Trico Oil & Gas Co. finished Seymour-Bolz No. 1, sec. 20,24-23, flowing 24,000,000 cu. ft. of gas from 2469 ft. and was shut in under 1075 lbs. pressure.

The company has poured foundation for Lee No. 1 to be drilled in the west half of sec. 17,24-23.

Pacific Oil & Gas Starts Pyramid Hills Development

Pacific Oil & Gas Development Corp. has assumed 320 acres of Tide Water Associated Oil Co. leases in sec.'s 20 and 29,24-18 in the Pyramid Hills area of Kings county, and is preparing to make a series of production trials in West Slope No. 1 which Tide Water completed pumping 20 bbls. of oil. Work will be done by Miller & York of Bakersfield with Vice-president B. B. Ellis in charge for the company.

This well made its small pumping production from Temblor sands below 850 ft. after bottoming in barren Cretaceous at 2087 ft.

Following the proposed exhaustive tests of the present hole the company proposes to drill West Slope No. 2 near the north quarter corner of sec. 20,24-18. If successful the

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company has plans for 20 wells on the acreage.

Hancock Completes Union Ave. Gasser

Hancock Oil Co.'s third effort in the tiny Union Avenue field, Roberts No. 3, located at the southerly limits of the city of Bakersfield just west of the State highway, has been completed from 66 ft. of Chanac zone bottomed at 4241 ft. flowing 500,000 cu. ft. of gas through a 5/64 in. bean Five bbls. of high gravity condensate was estimated to accompany the flow which marked up 1270 lbs. tubing pressure and 1420 lbs. of casing pressure. At last report the volume had increased to 600,000 cu. ft. with pressures and bean remaining constant.

The company's fourth effort in the discovery section 6,30-28, Roberts No. 4, is presently drilling in grass root stages at 765 ft.

Richfield Oil Corp. is drilling Union Avenue No. 2 in the same section at 2996 ft. Three years ago Richfield prospected for the fault accumulations, recently discovered, when it drilled Union Avenue No. 1 to 10,427 ft. with light rotary equipment and using a standard wooden rig in 1938-39. The deep test which excited considerable comment because of its depth and light rig employed was located just southwest of the center of the section.

Canal Deep Test Yet Above Vedder

Shell Oil Co.'s KCL No. A-44-14, deep exploratory hole in the center of the Canal oil field, is drilling and spot coring at 11,668 ft. Located in sec. 14,30-25, the deep well seeks Vedder zone production beneath the Stevens zone normally produced in the field and found present here at 8050 ft.

The belief that the deeper zone might be present is sponsored in part by the fact that both zones have proved productive in other central San Joaquin Valley fields.

Macrate Wildcat Fights Stuck D. P.

A. N. Macrate & Son's Haberfelde No. 1, McClung area wildcat, is spotting oil and attempting to loosen stuck drill pipe.

Located in sec. 32, 29-26, a mile and a half south of Greeley production, the well is bottomed at 12,025 ft. on the way to Vedder sands suspected to exist at this point near 12,250 ft.

Drilled in an effort to extend or duplicate Greeley production, the well has already found the Stevens zone, first Greeley zone, barren at 8090 ft. and is heading for the lower possibility.

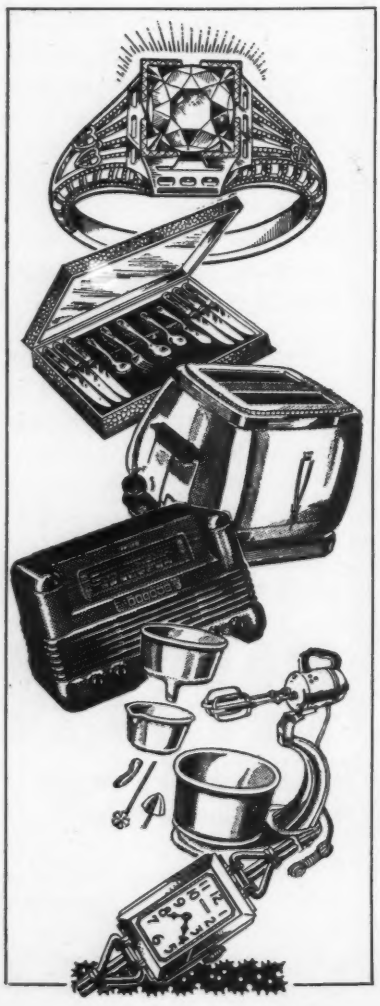
Paloma Development Shows New Spurt

With Western Gulf Oil Co. preparing to complete Symons No. 12-7 at a point one mile east of previous completion, and two further projects in preliminary stages, development of the Paloma field is looking up.

The Western Gulf extension, located in sec. 7,32-27, is recementing 7 in. casing at 11,265 ft. Bottomed in hard shale at 11,700 ft., the well will utilize oil sands encountered from 11,275 to 11,547 ft.

While approximately 700 ft. lower on structure than the nearest producer, the current well is expected to produce the large volume condensate and gas found higher in the field.

Western Gulf has also built derrick to drill L.A.A.C. No. 16-6 on lands of the Los Angeles Athletic Club in the southwest quarter of sec. 6,32-27.



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Coastal District

Continental Completes Big San Miguelito Well

Flowing initially at the rate of 1906 bbls. daily, Continental Oil Co. recently brought in Grubb No. 25 at San Miguelito. Gravity of the oil was 29 degrees, API, and the cut rapidly dropped from 9 per cent to clean. The gas flow was metered at 2,462,000 cu. ft.

No. 25 was bottomed at 6805 ft. and finished with a liner perforated at intervals below the 7-in. casing shoe at 5681 ft.

Rincon Outpost Drills at 5026 Ft.

Bond Development Co.'s No. 1, outpost well on the Tomson lease near the State Highway, was last reported as drilling at 5026 ft. without having yet encountered sands worthy of testing.

Chanslor-Canfield Midway Oil Co. is reconditioning both of its deep Rincon wells, Hobson No. C-3 being redrilled at 9621 ft. while casing is being pulled from No. C-9.

Richfield Oil Corp.'s Hobson State No. F-9 is being whipstocked under the sea at 3771 ft. Casing was cemented at 3085 ft.

Ventura Wildcat Developments Told

Undelayed so far by the usual winter storms, wildcat work throughout Ventura county is continuing at its normal fair weather pace.

Southwest of Santa Paula in sec. 21,3n-31w, Shell Oil Co. is again drilling ahead in Santa Paula y Saticoy No. 1 after setting surface casing at 980 ft. On Sespe Creek John Alford has spudded Goodenough No. 1 with a portable rotary and is drilling at a shallow depth while W. E. McCaslin is retesting his 2039 ft. Burson No. 1 on an adjoining property.

Hopland Oil Co.'s test of Oakridge Anticline in sec. 1, 3n-19w is temporarily idle at 4634 ft. in Sespe formation. It is planned to either test shallow showings or drill ahead in the immediate future.

In the Bardsdale area, Ventura Southern Oil Co. is drilling at 450 ft. in the shallow oil sands. Known as McCampbell No. G-1, the well is in sec. 19, 3n-19w.

Oil Production Maintenance, Ltd., is making a production test in Byhara No. 1, sec. 12, 4n-22w near Ojai, with the 1535 ft. hole plugged to 640 ft. At this writing production was mostly water but some oil was beginning to appear.

Brain & Kohler Finish Santa Maria Valley Well

With initial production gauging in excess of 400 bbls. a day of 13.5 gravity oil, Brain & Kohler, an affiliate of R. R. Bush Oil Co., completed Rembusch No. 2 at the south edge of the Santa Maria Valley field. The hole is open in the Monterey from 4822 to bottom at 5250 ft.

In sec. 26, 10n-34w, Palm Holding Co. brought in Bill Jr. No. 4 from 5275 ft. pumping 280 bbls. a day.

Latest completion in the west area was Union Oil Co.'s Le Roy No. 8 which bottomed at 5300 ft. and came in pumping 600 bbls. of 17 gravity oil with a high water content. Water shut-off was effected by cementing 7-in. casing at 4890 ft. Union's next scheduled completion is Stinson No. 7 in sec. 28 which has casing cemented at 4976 ft. and was last reported nearing final bottom at 5350 ft.

Assuring continued activity, eight strings of tools are now working in the field and as many more projects are in preliminary stages.

COASTAL COUNTIES WILDCATS

Area	Well	No.	Section	Depth	Status
Santa Barbara County					
Cat Canyon	Alphonzo E. Bell Corp., Gilmore	1	23, 9-33	6202	Swabbing
Careaga	Royalty Service Corp., Careaga	1	8, 8-33		Rigging up
Casmalia	Dolly Adams Oil Co., Marganti	2	13, 9-35		Location
	O. C. Field Gas. Corp., Righetti	2	13, 9-35	2190	Drilling
Lompoc	Alphonzo E. Bell Corp., Lompoc	6	28, 8-34		Grading
Santa Maria	John W. Lee, Trustee, T.G.	1	33, 10-33	100	Drilling
Ventura County					
Bardsdale	Hopland Oil Co., Well	1	1, 3-19	4634	Idle
	Ventura Southern Oil Co.	G-1	19, 3-19	431	Drilling
Conejo	Sycamore Oil Co., Boylan	1	23, 1-20	1700	Reaming
Ojai	Kelalee Pet. Co., Harvey	1	8, 4-21		Rig
	Oil Prod. Maintenance, Inc., Byhara	1	12, 4-22	1535	Pumps water
	Richfield Oil Corp., Ojai	44	13, 4-22		Grade
Piru	Pacific Western Oil Co., Temescal	11	4, 4-18		Grading
Santa Paula	Shell Oil Co., Inc., S.P.Y.S.	1	21, 3-21	985	Drilling
Sespe	Alford, J. A., Trustee, Goodenough	1	18, 4-19		Rigging up
	Ivers, H. A., Kentuck	13½	1, 4-20	865	Idle
South Mountain	Comstock Pet. Co.	1	17, 3-29	2250	Idle
	Loose, E. H., & Dietzmann, J.	1	17, 3-20	4200	Idle
Timber Canyon	Denison, A. T., Denison	1	13, 4-21	288	Idle
	Crude Oils. Inc., West	1	19, 4-20	927	Repairing equip.
	Henderson-Ortez Oil Co., O'Leary	1	29, 4-20		Rig

NORTHERN COUNTIES WILDCATS

County	Well	No.	Section	Depth	Status
Alameda	Shell Oil Co., Nissen	1	7, 2s-3e	6563	Abandoned
Colusa	Pacific National Pet. Corp.	1	17, 17n-4w		Rig
Madera	Blake, T. E.	2	22, 10s-17e		Rig
Mendocino	Keyt, N. F.	1	3, 12n-17w	1740	No report
Monterey	Loma Grande Oil Co., Corey	1	23, 24s-10e	3820	Testing
San Benito	The Texas Co., Carter	1	3, 17s-12e	2599	Drilling
Sutter	Buttes Oilfields, Inc.	7	3, 15n-1e	300	No report
Yuba	Wright, L. G., Cox	1	18, 14n-5e	1805	No report

(Continued from Page 19)

FIG. V

PISTON DISPLACEMENT IN THOUSANDS OF CUBIC FEET PER DAY AT 100 R.P.M.

		0.167 AL								
		L								
D	A	9″	10″	12″	14″	16″	18″	20″	24″	36″
3 ″	7.07	10.6	11.8	14.1	16.5	18.9	21.2	23.6	28.3	42.4
3¼″	8.30	12.5	13.9	16.6	19.4	22.2	24.9	27.7	33.3	49.9
3½″	9.62	14.5	16.1	19.3	22.5	25.7	28.9	32.1	38.6	57.9
3¾″	11.0	16.6	18.4	22.1	25.8	29.5	33.2	36.9	44.3	66.4
10 ″	78.5	118	131	157	183	209	236	262	314	471
10½″	86.6	130	144	173	202	231	260	289	346	520
11 ″	95.0	142	158	190	222	253	285	317	380	570
29 ″	660	991	1101	1321	1541	1761	1982	2202	2642	3963
30 ″	707	1060	1178	1414	1649	1885	2121	2356	2828	4241

PISTON ROD DISPLACEMENTS IN THOUSANDS OF CUBIC FEET PER DAY AT 100 R.P.M.

		0.0833 aL								
		L								
d	a	9″	10″	12″	14″	16″	18″	20″	24″	36″
1¼″	1.77	1.3	1.5	1.8	2.1	2.4	2.7	2.9	3.5	5.3
1¾″	2.41	1.8	2.0	2.4	2.8	3.2	3.6	4.0	4.8	7.2
2 ″	3.14	2.4	2.6	3.1	3.7	4.2	4.7	5.2	6.3	9.4
2¼″	3.98	3.0	3.3	4.0	4.6	5.3	6.0	6.6	8.0	11.9
2½″	4.91	3.7	4.1	4.9	5.7	6.5	7.4	8.2	9.8	14.7

CALCULATION:

$$\text{Disp.} = \frac{(2A - a)L \times 100 \times 1440}{1728 \times 1000} = 0.167\,AL - 0.0833\,aL$$

Example: 11″ x 16″ cylinder with 2¼″ rod.
Disp. = 253 − 5.3 = 248 thousand cu. ft. per day at 100 R.P.M.

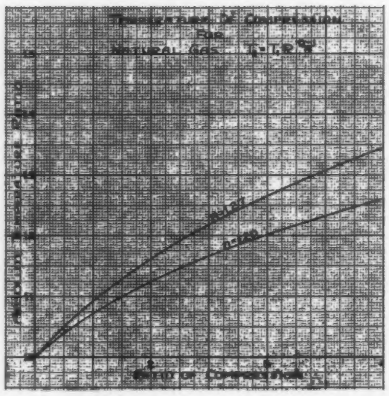
$$C = \frac{\text{Clearance in cu. in.}}{\text{Piston disp.}} \times 100 = \text{Percent cylinder clearance.}$$

one end:

$$C = \frac{Cl}{L(A - a)}, \text{ where } Cl = \text{Clearance in cu. in., that end.}$$
$$a = \text{piston rod area, that end, if any.}$$

total cylinder:

$$C = \frac{Cl}{L(2A - a)}, \text{ where } Cl = \text{Clearance in cu. in., total cylinder.}$$



data to cover all the possible combinations of conditions that exist outside of these limits. The second is an engineering recommendation to keep the controllable variables within these limits wherever possible. Keeping the ratio of compression down reduces ring and valve leak and wear by decreasing the pressure differential across them. The "R" can be controlled by suitable selection of cylinders. Comparatively low temperatures, maintained by adequate cooling and by low "R's", reduces carbon formation on the valves and rings which also reduces wear and maintenance costs. The gas gravity can not be controlled, but its effect on causing erroneous capacity and horsepower calculations can be minimized if the temperature and compression ratio are kept low. The deviation from a perfect gas at high pressure imposes the pressure limitation. At pressures up to 500 lbs. the deviation is negligible, and our calculations indicate that at discharge pressures up to 2,000 lbs. the error introduced by deviation will be within the limits of accuracy obtainable on the other variables.

Fig. II shows the volumetric efficiency curve that will be used in the bulletin. Remembering that in the high-"R" wet gas cards shown in Fig. I, the volumetric efficiency apparently decreased as the gravity and temperature increased, it is apparent that a volumetric efficiency curve for wet gas would show clearance lines with greater slopes than these. The convergence of these clearance lines as the "R" is decreased shows why the percentage error due to erroneous volumetric efficiency data is less when the "R" is less.

Fig. III shows the C. N. G. A. "Indicated Horsepower per Million Cubic Feet of Gas Compressed per Day" curve.

Figure IV shows the nomenclature sheet that will be presented in the proposed bulletin. It is virtually impossible to include all terms that might be used in engine and compressor work, or to avoid completely use of symbols that already have applications in mechanical, chemical, or physical fields. The proposed brief nomenclature is presented as being adequate for compressor calculations. The symbols used are in controversy with as few other nomenclature as is possible. Also included on this sheet are the formulas for calculating capacity and horsepower.

Fig. V shows a section of the displacement table which is worked up for cylinder diameters in quarter-inch increments from 3" to 10", in one-half inch increments from 10" to 20", and in 1" increments from 20" to 30". The displacements for these bores in thousands of cubic feet per day are given for 9", 10", 12", 14", 16", 18", 20", 24" and 36" strokes at 100 R. P. M. Constants, covering the various rod diameters found in the industry, are supplied so that they may be subtracted directly from the bore--stroke displacement used.

Fig. VI shows the C. N. G. A. "Temperature of Compression" curve which provides a means of calculating the gas discharge temperature inside the compressor cylinder. The temperature drop through the discharge valves, gas chamber, and piping must be subtracted from this value to obtain the gas temperature in the pipe line. This curve is also subject to the boundary limits outlined above.

The bulletin will consist of these three curves and the two tables, and will show sample calculations covering the several different approaches used in normal compressor computations.

In closing may I repeat that this proposed bulletin is not intended as a treatise on compression; that it is simply a presentation in usable form of the data now used in compressor calculations which is known to be accurate within certain limits; that these limits present considerable liabilities in certain cases, but that in the greater percentage of our compressor installations these limits are adequate or can be made to be so; and that this publication is a tentative first step towards realizing the long-sought goal of a C. N. G. A. Gas Engine and Compressor Handbook.

Dolly Adams Starts New Casmalia Well

Dolly Adams Oil Co., following the lead of O. C. Field Gasoline Co., is preparing to drill a new well in the Casmalia field. Location of the project, Morganti No. 2, is approximately 800 ft. south and 3400 ft. east of the northwest lease corner in sec. 13, 9n-35w.

The O. C. Field well, Righetti No. 2 in the same section, was last reported drilling at 2100 ft.

Martin-Decker Mud Logger Charts Mud Weight and Viscosity

Martin-Decker Corp., Long Beach, California, has recently announced development of an instrument that provides a clear, continuous record of mud weight and viscosity while drilling. Known as the Martin-Decker Mud Logger, it permits direct readings of these two important factors to be made at all times, thus enabling complete control of mud condition to be maintained continuously.

To obtain viscosity readings, the Mud Logger uses a method that is simple, practical and highly accurate. Since the absolute viscosity of a fluid is its internal resistance to shear, the unit was designed to make full use of this shear principle. The instrument consists essentially of (1) a sturdy, constant speed induction motor suspended on roller bearings and free to turn radially, (2) a rotor connected to the motor armature through a steel shaft, and (3) a simple two-pen recorder actuated by movements of the motor. The solid metal rotor is enclosed within a cage of stationary vanes. The unit is suspended over the mud ditch with the rotor submerged in the mud stream. There is no interference with the uniform mud flow.

Viscosity Recorded Automatically

As the rotor shears the mud between its surface and the stationary vanes, the torque exerted by the rotor is directly proportional to the viscosity of the fluid. Thus the tendency of the suspended motor housing to turn with the armature or rotor gives a measure of the torque on the rotor. This torque measurement is calibrated in units of viscosity (centipoises) and direct records of mud viscosity are thus obtained. These records can be used for viscosity comparisons of all **weights** of mud.

Mud Weight Charted

A record of mud weight is also obtained by the rotor. Since the rotor is free to move up or down a short distance, it will "float" at a level dependent upon the buoyant effect, or weight, of the mud passing across the rotor. Positions of the rotor are calibrated in pounds per cubic foot of mud weight, enabling a continuous record of this factor to be penned on the chart.

Obtains Valuable Information

Information obtained with the Martin-Decker Mud Logger is a valuable aid both to the driller and to the mud engineer. It enables the driller to keep his mud in proper condition at all times during all stages of drilling. In mud treating, charts obtained show that definite high and low points are present in the mud cycle. Thus, by adding chemicals only at points in the cycle where required, treating costs can be reduced. This treating method is an important advancement over the old system of adding chemicals continuously. Furthermore, waste of new mud can be virtually eliminated, since the chart will show which sections of the mud require replacement and which can be saved.

As an aid to drilling safety, speed and efficiency, the Mud Logger offers outstanding advantages. Channeling—frequently a forerunner of stuck drill pipe—can be detected with the instrument simply by noting changes in the circulating period. Changes in mud weight make detection of water loss a simple matter, and afford a check on filter cake efficiency. Where mud weight is a vital factor—such as when gas is encountered—the disastrous hazard of undetected weight changes can be avoided. The Mud Logger also provides a convenient and practical means of studying effect of various sand characteristics on the speed and efficiency of drilling.

Further details concerning the Martin-Decker Mud Logger may be obtained by writing direct to Martin-Decker Corp., Long Beach, Calif.

Bulletin on Clark Steam Driven "Angle"

Clark Bros. Co., Olean, New York, have announced that a bulletin is now ready for distribution on the new Clark "Angle" Steam Engine Driven Compressor. Clark Bros. will be glad to send this bulletin, No. 200-73, to engineers and others desiring it. Requests should be sent to the company's home office.

C. J. Coberly Director of Consolidated Steel Corp.

Clarence J. Coberly, president of Kobe, Inc., was elected a director of Consolidated Steel Corp., Ltd., at its recent meeting of the board of directors. Mr Coberly will fill the vacancy which occurred on the death of Donald G. Henderson

Mr. Coberly, long prominent in the engineering field, is well known to Southern California business men. He was graduated from Stanford University in 1915, and for three years he was engaged in oil well tool manufacturing. Early in 1918, he became identified with the California Compressed Gas Co. in charge of engineering, and it was he who designed and perfected the well known "Purox" equipment. With the development of Signal Hill, Santa Fe Springs, Torrance and Baldwin Hills oil fields, Mr. Coberly recognized the need for scientifically engineered well screen. His research along this line resulted in the invention of the Kobe Process and pipe slotting equipment, now covered by more than forty U. S. and foreign patents.

C. J. Coberly

Kobe, Inc, was formed in September 1923, and the company derived its name from the nickname by which Mr. Coberly has always been known.

Mr. Coberly has also developed the Kobe Hydraulic Oil Well Pump, which operates successfully from depths as great as 9,750 feet.

He is a member of the A.S.M.E., A.I.ME., the A.P.I., the Los Angeles Athletic Club, the California Club, the University Club, and the Los Angeles Yacht Club. His hobbies are photography, in both the technical and general aspects, and sailing.

Frank W. Morris Heads Spang Chalfant Coast Sales

Spang Chalfant, Inc. has announced the appointment of Frank W. Morris as manager of sales, West Coast Territory, effective Nov. 10, 1941, succeeding J. V. Greer, resigned.

Mr. Morris' headquarters will be in the Ohio Oil Building, Los Angeles. Frank Morris has been associated with the Spang Chalfant sales organization for a number of years and just recently was manager of sales for the Dayton Pipe Coupling Division of National Supply Co. in Pittsburgh.

J. P. Getty Spuds Edison Wildcat

J. Paul Getty's Portals No. 1, Edison area wildcat in the southwest quarter of sec. 5,30-29, is drilling at 2310 ft. after cementing 10¾ in. casing at 511 ft.

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(Continued from Page 17)

from the liquid phase per differential weight of material withdrawn from the system may be established from the following equality:

(13)

$$\underset{k}{dm} = \underset{k}{Y}\, dm$$

From this expression the change in volume of the liquid phase may be established in the following fashion:

(14)

$$dV = \sum_{k=1}^{k=n} \overline{V}_k\, dm$$

Equation 14 may be rewritten to yield the rate of change in volume of the liquid phase:

(15)

$$\frac{dV}{dm} = \sum_{k=1}^{k=n} Y_k \overline{V}_k = \frac{\sum_{K=1}^{K=n} K_k X_k V_k}{\sum_{K=1}^{K=n} K_k X_k}$$

This equation involves only the assumption that the change in weight of the gas phase is negligible in comparison to the change in weight of the liquid phase. In cases where this change is not negligible it may be taken into account without undue complications.

The two foregoing applications indicate only briefly the way in which partial volumes may be employed in connection with the solution of engineering problems relevant to systems of variable weight. The application of such methods to the prediction of the specific volumes of the liquid and gas phases of multicomponent hydrocarbon systems has not been reviewed since such discussions (2, 12) are available in the literature.

Acknowledgement

The authors wish to express their appreciation to the Industry for its continued support of experimental activities which will lead to a better understanding of the behavior of hydrocarbon mixtures under the conditions which are encountered in underground reservoirs, natural gasoline plants, and refining operations. The assistance of Louise M. Reaney and Betty R. Camomile in connection with the preparation of the figures is acknowledged.

b—Specific gas constant (R/M).
K—Gas-liquid equilibrium constant.
m—Weight of system, pounds.
M—Molecular weight.
N—Weight fraction.
P—Pressure, pounds per square inch absolute.
R—Universal gas constant.
T—Thermodynamic temperature, °R.
V—Specific volume, cubic feet per pound.
V—Total volume, cubic feet.
$\overline{V}$—Partial volume, cubic feet per pound.
X—Weight fraction in a liquid phase.
Y—Weight fraction in a gas phase.
δ—Partial derivative.
Δ—Finite difference, or increment.

Subscripts

$_{1,2 \cdots n}$—denote components $_{1,2 \cdots n}$.
$_i$—denotes all components of a system other than component k.
$_k$—denotes component k.
$_l$—denotes liquid phase.

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